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PAPERS AND PROCEEDINGS OF

The Royal Society of Tasmania

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- 4 JAN 1977
OF VICTORIA

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November 1976

Volume 110

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OFFICE BEARERS 1975

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His Excellency the Governor of Tasmania, Sir Stanley Burbury

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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA

VOLUME 110

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ROYAL SOCIETY OF TASMANIA

ANNUAL REPORT FOR THE YEAR 1975

The Council has the honour to present to members the following report on the activities of the Society during the year.

COUNCIL AND OFFICE BEARERS

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Mr D.R. Gregg

Honorary Treasurer
Mr G.E.A. Hale

Honorary Auditor
Mr D.B. Churchill

Honorary Editor
Mr M.R. Banks

PRESIDENT

Sir Stanley Burbury, took the Chair, as President of the Society, at the Annual General Meeting and at the July General Meeting.

HONORARY LIFE MEMBER

Dr C. Craig was elected an Honorary Life Member in recognition of his contribution to the Society and to the knowledge of the history of Tasmania.

ANNUAL MEETING

At the Annual Meeting on 4 March, Dr W. Bryden retired as Vice-President, and Mr. E.C. Gifford and Mr K.D. Nicolls as Members of the Council. The following were elected -

Vice-President	-	Mr K.D. Nicholls
Members of Council	-	Dr W. Bryden
	-	Dr E.A. Colhoun
Honorary Secretary	-	Mr D.R. Gregg
Honorary Treasurer	-	Mr G.E.A. Hale
Honorary Auditor	-	Mr D.B. Churchill

A casual vacancy on the Council resulting from the resignation of Mr A.J. Dartnall was filled by the election of Mr R.J. Downie.

LECTURES

The following lectures were given in Hobart during the year -

March	"On elevating a penal colony: John Lillie and Jane Franklin"	Mr P.W. Boyer, Tasmanian Museum
	"Holiday with fish"	Dr June Olley, C.S.I.R.O., Hobart
April	"Some aspects of research management"	Dr A.E. Martin, C.S.I.R.O., Hobart
May	"Research in national parks"	Mr M.R. Banks, University of Tasmania
		Mr N.K. Vallance, Tasmanian Conservation Trust
		Mr P. Murrell, National Parks and Wildlife Service
June	"The effect of media on public attitudes"	Mr John Levett, Tasmanian College of Advanced Education.
July	"Sentencing and the two cultures"	Mr. Justice Green, Chief Justice of Tasmania
August	"Environmental management in Australia - a challenge for co-operative federalism"	Dr D.F. McMichael, Department of Environment and Conservation, Canberra.
September	"Why inflation and unemployment"	Professor K. McB. Grant, Faculty of Commerce, University of Tasmania
October	"International co-operation in Antarctica"	Dr R.I. Garrod, Antarctic Division, Department of Science and Consumer Affairs, Melbourne
November	"An anatomist's appreciation of the body"	Professor R. Wheeler Haines, Department of Anatomy, University of Tasmania

NORTHERN BRANCH

The Northern Branch of the Society based in Launceston had the following Council -

Chairman	-	Dr E.V.R. Ratcliff
Vice-Chairman	-	Mr P.G. Webb
Past Chairman	-	Mr D. Walter
Members	-	Mr C.F.L. Nieuwhof
	-	Mr A.T. Orr
	-	Mr H.S. Payne
	-	Mr N.J.B. Plomley
	-	Mr G.H. Stancombe
Honorary Secretary	-	Mr T.E. Burns
Honorary Treasurer	-	Mr J.D. Abey

Mr K.E.J. Robinson, a retiring councillor, was elected to continue as a Northern Branch representative on the Council of the Society.

The following lectures were given -

March	"Notable buildings of Northern Tasmania"	Mr G.H. Stancombe
April	"Regional planning in Tasmania"	Mr C.G. Pryor
May	"The anatomy of shipwreck"	Mr R.A. Ferrall
June	"Managing Tasmanian commercial fishing resources"	Mr A.J. Harrison
July	"The Hunter Report"	Alderman Barbara Payne
August	"The History of St John's Church, Launceston	Mr P.G. Webb
September	"A Tasmanian Aboriginal Dictionary"	Mr N.J.B. Plomley
October	"Nathaniel Lipscombe Kentish"	Mr T.D. Sprod
October	"An assessment of Tasmanian historians"	Mr John Reynolds
November	"Aspects of Tasmanian educational history"	Mr C. Bryce Ward
December	(Members' Night)	
	"Oracles and oleanders (on remains of ancient Greece)"	Mrs Pixie Thomas
	"The first aerial post"	Commander E.J. Prevost
	"What happened to the Sunday school picnic?"	Mr P.G. Webb
	Hannah Wilson, a battler from Yorkshire"	Mrs Joan Gardner

An excursion to the East Tamar area was held in April.

The President took the Chair at the Annual Meeting of the Branch in March. At the November meeting members of the Auckland Historical Society from New Zealand were present and an historical excursion was arranged for them during their visit.

PUBLICATIONS

During the year, the Society published a further volume of the Papers and Proceedings and a special publication arising from the Bicheno Symposium of November 1974 on "Resources of the Sea."

Volume 109 of the Papers and Proceedings was published in December;the active interest and assistance of officers of the Government Printer deserve special mention. The volume contained 16 papers on subjects ranging over many fields of natural science. The new cover design seems to have met with wide approval.

The book "Resources of the Sea", published in September, contained the text and illustrations of the nine addresses given at the Bicheno Symposium.

The Society is indebted to Mr Banks for his work as Honorary Editor.

MEMBERSHIP

During the year the membership was 551 an increase of 11.

The membership is made up as follows -

	Northern Branch	Total
Honorary Life Members		5
Life Members	9	33
Ordinary Members, receiving Papers and Proceedings	91	281
Ordinary Members, not receiving Papers and Proceedings	116	206
Associate Members	20	26
	236	551

COUNCIL MEETINGS

The Council met four times during the year, Dr E.V.R. Ratcliff and Mr K.E.J. Robinson represented the Northern Branch on the Council. Mr G.H. Stancombe took the place of Dr Ratcliff at two meetings.

REPRESENTATIVES ON OTHER BODIES

Mr M.R. Banks and Dr D. Martin continued to represent the Society on the Trustees of the Tasmanian Museum and Art Gallery. Dr M. Hurburgh was re-appointed representative of the Society on the Trustees of the Royal Tasmanian Botanical Gardens.

ACKNOWLEDGEMENTS

The Council is grateful for help generously given by many individuals and organisations. In particular, the lecturers, the Government of Tasmania, the University of Tasmania, the Tasmanian Museum and Art Gallery, and the Queen Victoria Museum and Art Gallery are specially thanked for their help and co-operation.

THE ROYAL SOCIETY OF TASMANIA

BALANCE SHEET AS AT 31st December, 1975

Accumulated Funds		$65,028.21	Cash on Hand		$ 20.00
Subscriptions in Advance		51.00	Cash at Bank -	General Account	4,650.83
Trust Funds :-			-	Papers & Proceedings A/C	6,519.07
Clive Lord Memorial Fund	1,080.47		-	Clive Lord Memorial Account	380.47
A.N. Lewis Memorial Fund	1,657.06		-	A.N. Lewis Memorial Fund	557.06
Morton Allport Memorial Fund	709.65		-	Publication Account	532.20
A.H. Clark Bequest	317.27		Mortgage Loan -	Perpetual Trustees	860.00
Joseph Milligan Bequest	2,120.99		Commonwealth Treasury Bonds & Inscribed Stock (at cost)		10,430.00
R.M. Johnston Memorial Fund	1,056.20		Library (at valuation for insurance)		15,000.00
Henry Oliver Bequest	481.14		Stock of Publications on Hand (at selling prices)		36,500.00
W.H. Hudspeth Memorial Fund	1,222.37				
Life Membership Fund	1,725.27	10,370.42			
		$75,449.63			$75,449.63

LAYH, HART, ROOM & HYLAND

13th April 1976

Papers and Proceedings of the Royal Society of Tasmania, Vol.110, 1976.

(ms. received 14.4.1975)

LATE MIDDLE CAMBRIAN AGNOSTID TRILOBITES FROM THE GUNNS PLAINS AREA, NORTH-WESTERN TASMANIA

by J.B. Jago
School of Applied Geology, South Australian Institute of Technology

(with one table, three text-figures and two plates)

ABSTRACT

Ten species of agnostid trilobites, including a new species, *Utagnostus*(?) *nevel*, are described from two localities within the lower sedimentary succession of the Radfords Creek Group, Dial Range Trough, north-western Tasmania. The faunas from both localities (near Gunns Plains) are of late Middle Cambrian age; one is either of the *Lejopyge laevigata* II Zone or the *L. laevigata* III Zone and the other is either of the *L. laevigata* III Zone or the *Damesella torosa-Ascionepea janitrix* Zone.

INTRODUCTION

The purpose of this paper is to describe all known undescribed agnostid trilobites from the lower sedimentary sequence of the Radfords Creek Group of the Dial Range Trough, north-western Tasmania. Two localities are involved, (fig. 1): (i) road cuttings on the main road to Gunns Plains (lat. 41°16.1'S, long. 146°03.7'E) and (ii) an old timber track on the western side of the Leven River (lat. 41°15.4'S, long. 146° 04.2'E).

STRATIGRAPHY

The Radfords Creek Group consists essentially of an upper and a lower sedimentary sequence separated by the keratophyric Applebee Volcanics (Burns 1964). The lower sedimentary succession is best exposed in what Burns (1964) termed the Sugarloaf Gorge, particularly along cuttings of the main road to Gunns Plains, and along an old timber track along the western side of Sugarloaf Gorge.

In the Sugarloaf Gorge area near Gunns Plains, Banks (1956) and Burns (1964) and the writer have measured part of the lower sedimentary sequence of the Radfords Creek Group (Table 1). The total thickness of the Radfords Creek Group exposed in this sequence (units 2 to 15) is about 765 metres. Burns (1964, p.48) noted a thickness of about 380 metres for the same sequence. He considered that even this thickness was excessive and that it was due largely to tectonic repetition. Tectonic repetition is probable (see below), but not to the extent suggested by Burns. An inspection of the outcrops along Gunns Plains Road in Sugarloaf Gorge indicates that units 10, 11, 12, 13, 14 and the upper part of unit 15 (a thickness of over 200 metres) are in continuous sequence with only minor faulting. Unit 15 appears to have a stratigraphic thickness of 460 metres along the road, although outcrop is discontinuous and there is the possibility of repetition by faulting.

Fossils have been found in three of the units noted in Table 1. Banks (1956) reported *Clavagnostus* from unit 15. The writer was unable to relocate *Clavagnostus* but found a single, poorly preserved, almost complete specimen of *Tasagnostus* sp. about 10 metres from the top of unit 15. Unit 13 is moderately fossiliferous with only trilobites being found to date (with the possible exception of one echinoderm plate, see pl. 2, fig. 8). Agnostid trilobites described herein from unit 13 are *Hypagnostus* cf. *brevifrons* (Angelin), *Pseudophalacroma*(?) sp., *Ptychagnostus (Goniagnostus)* sp.,

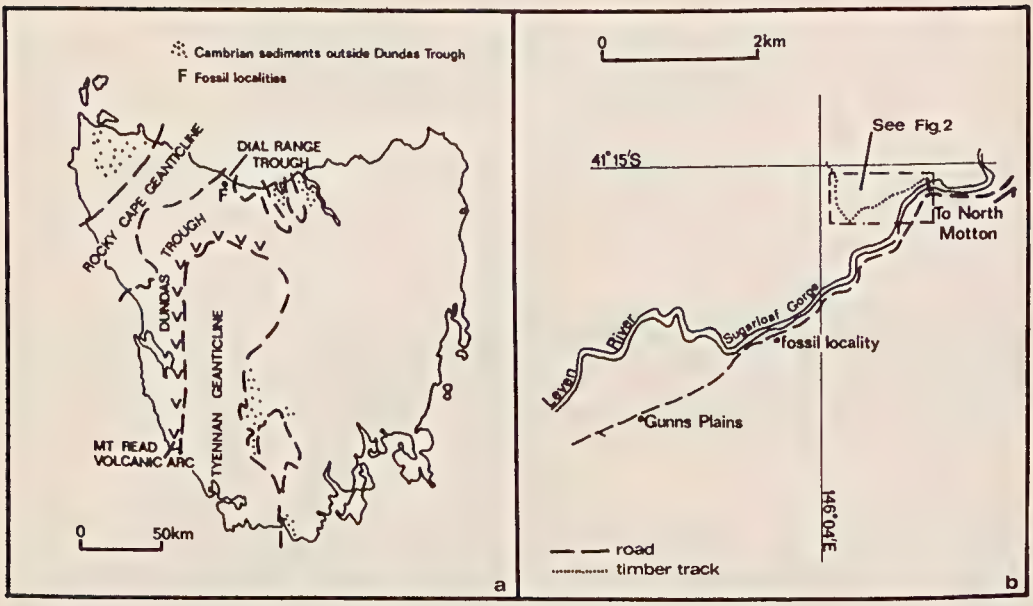


FIG. 1 - (a) Tasmanian Cambrian palaeotectonic framework (after Corbett *et al.*, 1972)
(b) Locality map.

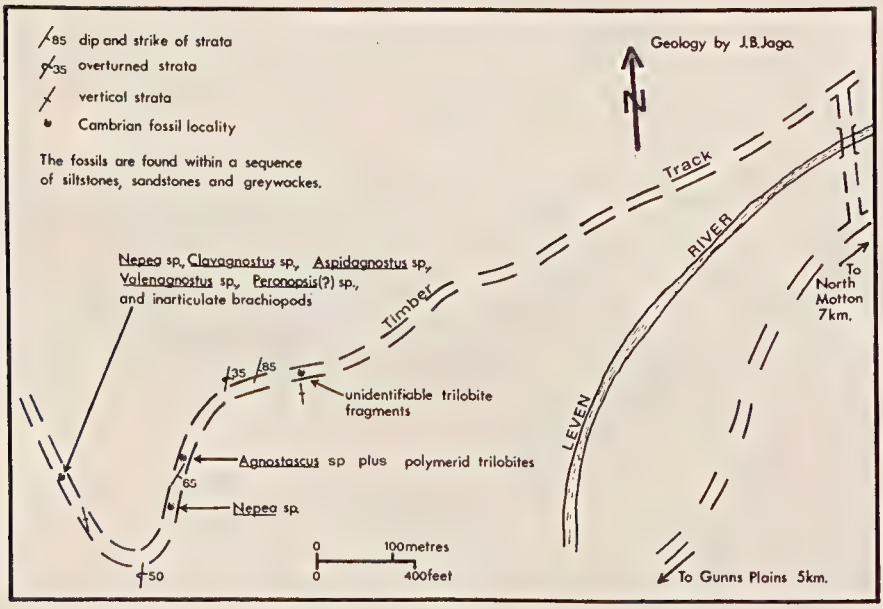


FIG. 2 - Geological sketch map of an area along an old timber track on the west side of Sugarloaf Gorge.

TABLE 1

SECTION THROUGH RADFORDS CREEK GROUP IN THE SUGARLOAF GORGE

(near lat. 41°16.1'S, long. 146°03.7'E)

(Modified after Banks 1956, Burns 1964)

	UNIT	METRES
Top		
	Gordon Limestone (Junee Group)	
	Fault	
	1. "West conglomerate" (Junee Group)	37
	Inferred unconformity	
	2. Brecciated greywacke	26
	Major Fault	
	3. "Middle conglomerate"	13
	4. Mudstone with *Ptychagnostus* near top	22
	5. Tuff	5.5
	6. Mudstone	18
	7. Greywacke	4
	8. Mudstone	33
	9. Greywacke sandstone, conglomerate and tuff	14
	Major Fault	
	10. "East conglomerate"	23
	11. Mudstone	19
	12. Tuff, lava	19
	13. Argillite with *Lejopyge*, *Ptychagnostus*, *Pianaspis*(?) *leveni*, etc.	90
	14. Tuff and lava	19
	15. Argillite with *Tasagnostus* (near top)	460
Break ??		802.5
Sprent Formation		
Base		

N.B. The unit numbers are the same as given by Burns (1964, p.47). They are retained for the sake of uniformity.

?Lejopyge laevigata (Dalman), *L. l. armata* (Linnarsson), *Utagnostus*(?) *nevel* sp. nov. and *Diplagnostus* sp. *Pianaspis*(?) *leveni* Jago was described in Jago (1974b). There are also a large number (Table 2) of unassigned effaced agnostids, which probably belong in either *?Lejopyge laevigata, L. l. armata,* or *Pseudophalacroma*(?). The distribution of the trilobites in unit 13 is shown in figure 3. The palaeoecological significance of this distribution is discussed in Jago (1973). This fauna is probably of *Lejopyge laevigata* II Zone or *L. laevigata* III Zone (Jago 1974b). The discovery by the writer of one specimen of *Ptychagnostus* (too poorly preserved to figure or describe) near the top of unit 4 lends some support for Burn's suggestion of tectonic repetition.

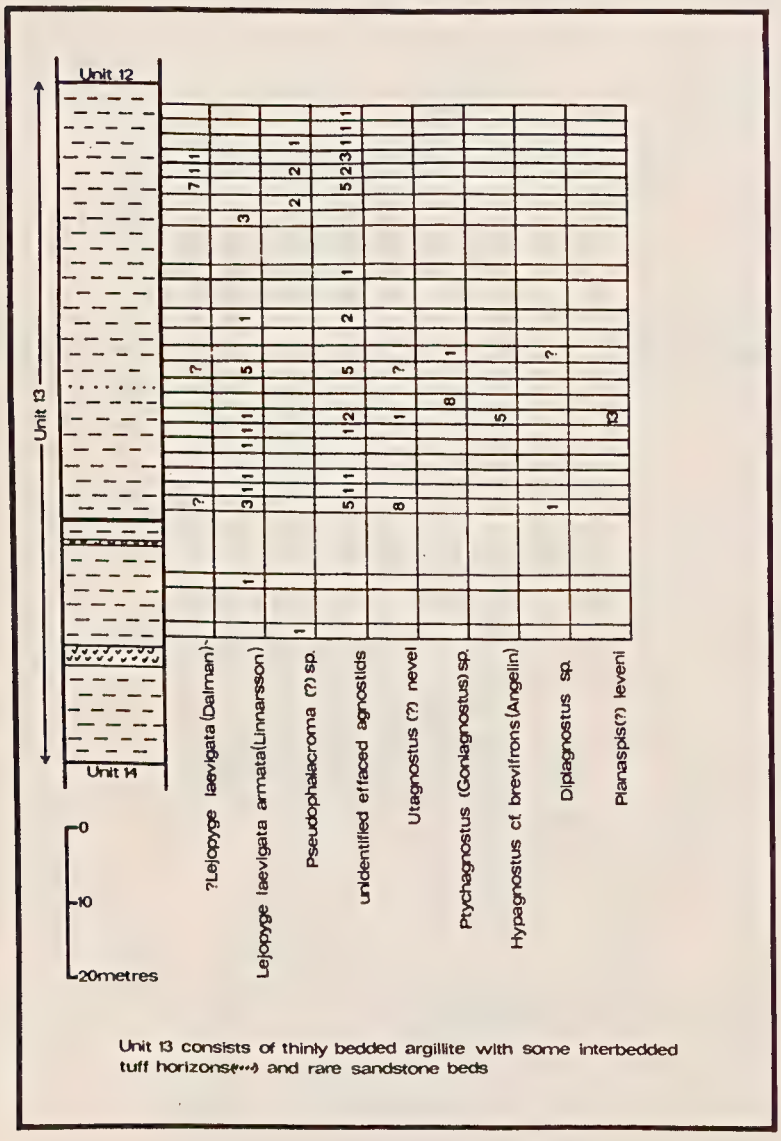


FIG. 3 - Stratigraphic distribution of trilobite species in unit 13 of Sugarloaf Gorge road section of Burns (1964). All specimens collected by the writer from this unit are tabulated. The unidentified effaced agnostids probably belong in *?Lejopyge laevigata, L. laevigata armata* and *Pseudophalacroma*(?) sp.

Stratigraphically above the fauna with *Lejopyge*, Banks (1956, p.185) found trilobites within a highly folded sequence exposed along an old timber track on the west side of Sugarloaf Gorge (fig. 2). Four poorly fossiliferous horizons are known near lat. 41°15.4'S, long. 146°04.2'E. The lowest exposed bed of this sequence, a siltstone, contains inarticulate brachiopods plus the trilobites *Nepea* sp., *Aspidagnostus* sp., *Valenagnostus* sp., *Clavagnostus* sp. (described and figured in Jago and Daily 1974) and a possible *Peronopsis* (too poorly preserved to describe or figure). *Agnostascus* sp., *Nepea* and other trilobites occur slightly higher in the section (fig. 2). This fauna is very similar to the main fauna from St. Valentines Peak which has an age of either *Lejopyge laevigata* III Zone or *Damesella torosa-Ascionepea janitrix* Zone (Jago 1973).

PALAEONTOLOGY

In common with other Tasmanian Cambrian fossils the trilobites described below have undergone tectonic distortion. Henningsmoen (1960, p.207) noted that there are three main types of symmetrical distortion with respect to the orientation of bilaterally symmetrical fossils such as trilobites: (a) a dorso-ventral flattening, (b) where the length is enlarged with respect to the width, L form and (c) where the width is enlarged with respect to the length, W form. Those fossils in which the distortion has been asymmetrical are stated here to have undergone intermediate distortion (i.e., the compression took place at an oblique angle to the length of the trilobite). In cases where no comment is made about the type of distortion, it is because little distortion has taken place. Unless otherwise stated, all length measurements noted in this paper were taken along the axis of the trilobites; all width measurements were taken parallel to the anterior end of the pygidium, or parallel to the posterior end of the cephalon.

All specimens described here are preserved as external or internal moulds. Where possible silicone rubber casts of the external moulds were prepared. All figured specimens were photographed after being whitened with magnesium oxide. All catalogue numbers refer to the collections of the Geology Department, University of Tasmania.

This paper completes the descriptions of all known trilobites from the road cutting on the main road to Gunns Plains. The polymerid trilobites from the old timber track will be described in conjunction with those from St. Valentines Peak. The taxonomic terminology used in this paper is after Öpik (1961a, 1963, 1967). The agnostid trilobite classification of Öpik (1967) is followed here.

SYSTEMATIC DESCRIPTIONS

Order Miomera Jaekel, 1909
Suborder Agnostina Salter, 1864
Superfamily Agnostacea M'Coy, 1849
Family Agnostidae M'Coy, 1849
Subfamily Quadragnostinae Howell, 1935

Genus *HYPAGNOSTUS* Jaekel, 1909

Synonymy: See Jago 1976
Type Species: *Agnostus parvifrons* Linnarsson 1869, p. 82, pl. 2, figs. 56, 57.
Diagnosis: See Robison 1964, p. 529.

Hypagnostus cf. *brevifrons* (Angelin)
pl. 1, figs. 1-4

Synonymy: See Jago 1976
Material: Two small, very poorly preserved complete specimens are available as well as two cephala and two pygidia of moderate preservation.

Measurements: UT 92492, cephalon, W form, length, about 2.0 mm, width, 2.5 mm: UT 92493, pygidium, L form, length, 1.9mm.
Comments: This form is indistinguishable from the form described by Jago (1976) as *Hypagnostus* cf. *brevifrons* (Angelin) from the upper fauna at Christmas Hills.
Occurrence: *Hypagnostus* cf. *brevifrons* (Angelin) comes from unit 13, lower sedimentary sequence of Radfords Creek Group, Gunns Plains Road, lat. 41°16.1'S, long. 146°03.7'E.

Genus *VALENAGNOSTUS* Jago, 1976

Valenagnostus Jago, 1976.
Type Species: *Agnostus nudus* Beyrich var. *marginata* Brögger, 1878, p. 73, pl. 6, fig.3.
Diagnosis: See Jago 1976.

Valenagnostus sp.
pl. 1, fig. 5

One poorly preserved internal mould of a pygidium (UT 92498) of *Valenagnostus* is known from the lowest fauna on the timber track on the west side of the Sugarloaf Gorge. It has a very prominent terminal axial node, and it may belong to *Valenagnostus banksi*. However, no firm determination can be made.

Genus *PSEUDOPHALACROMA* Pokrovskaya, 1958

Pseudophalacroma Pokrovskaya 1958, p. 79, Öpik 1961b, p. 90; Chu, 1965, p. 139.
Type Species: *Pseudophalacroma crebra* Pokrovskaya 1958, p. 79, pl. 3, figs. 4-6.
Diagnosis: See Öpik 1961b, p. 90.

Pseudophalacroma(?) sp.
pl. 1, figs. 6-8

Material: Several complete specimens in a poorly to moderately preserved condition are available. Several individual cephala and pygidia in a similar state of preservation are known. The following description is based mainly on specimens UT 92500 (the best preserved external mould pl. 1, fig. 8) and UT 92501 (the best preserved internal mould pl. 1, fig. 7).
Measurements: UT 92500, L form, total length, 5.3mm; cephalon, length, 2.7mm, width, 2.2mm; pygidium, length, 2.4mm (without articulating half ring), width, 2.0mm: UT 92501, internal mould, L form, total length, 6.3mm; cephalon, length, 2.7mm, width 2.3mm; pygidium, length (without articulating half-ring), 2.5mm, width, 2.4mm.
Description: The strongly convex cephalon is probably about as wide as long. The border is narrow. The narrow rim is difficult to see due to the very steep sides of the acrolobe; the rim appears to be a continuation of the acrolobe with the outline of the cephalon being interrupted by the narrow, shallow marginal furrow. There are short posterolateral spines. The cephalon is almost entirely effaced with only the posterior end of the glabella being outlined. The cephalon has a steep posterior end. The basal lobes are small and simple with a very narrow connecting band between them which passes under the broadly rounded glabellar rear. The basal lobes are outlined by shallow furrows; the axial furrows do not extend past the anterior ends of the basal lobes. The rest of the cephalon appears to be smooth. The pygidium is probably about as long as is wide. It is considerably less convex than the cephalon and has a truncated anterior end. The wide border is composed of a wide, elevated strongly convex rim which narrows considerably to the anterior and a wide deep marginal furrow. At the posterior the border has a length (sag.) about 0.15 that of the pygidium. The shoulder furrows are moderately wide and deep; the convex shoulders are of moderate width; the fulcra occur just over half way from the anterolateral corners to the axial furrows. The axis is outlined only in its anterior region. It consists of at least two lobes, the more posterior of which is narrower (tr.) than the other. A small node is present on the second axial lobe; it is also the highest point on the axis but is not visible on the photographs of these specimens. At the anterior the

axis has a width about 0.45 that of the pygidium. The axial furrows are shallow but distinct along the first axial lobe. They can be barely made out along most of the second axial lobe, to the posterior of which they vanish. The pleural fields appear to be smooth.

Discussion: This species is tentatively referred to *Pseudophalacroma* Pokrovskaya rather than *Valenagnostus* because (1) the glabellar rear and posterior portions of the basal lobes are better outlined than in *Valenagnostus*, (2) the pygidial border is somewhat narrower than that of *Valenagnostus*, (3) there is no terminal pygidial axial node. *Pseudophalacroma*(?) sp. described above may be related to *Pseudophalacroma* sp.K of Öpik (1961b, p. 94, pl. 22, fig. 12).

Occurrence: *Pseudophalacroma*(?) sp. comes from unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road.

Subfamily Ptychagnostinae Kobayashi, 1939
Genus *PTYCHAGNOSTUS* Jaekel, 1909

Synonymy: See Robison 1964, and Jago 1976.
Type Species: *Agnostus punctuosus* Angelin, 1851, p. 8, pl. 6, fig. 11.
Diagnosis: See Robison 1964, p. 522

Ptychagnostus (Goniagnostus) sp.
pl. 1, figs. 9-15

Material: Several poorly to moderately well-preserved cephala and one poorly preserved complete specimen, UT 92519, are available. No well-preserved, complete pygidium is available. However, specimen UT 92520 has a fairly well-preserved, incomplete pygidium. The description of the pygidium is based mainly on this specimen. All specimens except one cephalon (UT 92521) and one poorly preserved pygidium (UT 92522, not figured) are internal moulds.

Measurements: UT 92520, length of glabella, 3.0mm: UT 92523, cephalon, length of acrolobe, 2.3mm, width of acrolobe, 2.3mm: UT 92524, cephalon, length, 4.0mm: UT 92525, small complete specimen; cephalon, length, 1.9mm, width, 2.0mm; pygidium, length, 1.7mm, width, 1.7mm: UT 92526, cephalon, length, 3.1mm, width, 3.3mm: UT 92521, cephalon, length of acrolobe, 2.5mm, width of acrolobe, 2.3mm: UT 92519, pygidium, length, 2.0mm, width, 2.1mm.

Description: The cephalon is about as wide as long. The border is composed of a narrow, shallow marginal furrow and a narrow, upraised rim. The cheeks are highly scrobiculate. There is a wide, moderately deep preglabellar median furrow. The glabella is outlined by deep, moderately wide axial furrows; it has a length approximately 0.7-0.8 that of the cephalon (the nature of the specimens does not allow a more accurate determination). There is a wide, moderately deep transverse glabellar furrow. The anterior glabellar lobe is subtriangular with a broadly rounded anterior end; it has a length approximately 0.4 that of the glabella. At the transverse glabellar furrow the glabella has a width approximately 0.3 that of the acrolobe. The posterior glabellar lobe is trilobed (including the basal lobes) with two evenly spaced pairs of lateral glabellar furrows. Each of the anterior pair of lateral furrows extends across about one-third of the glabella from the axial furrows. The anterior lateral furrows are wide and deep. The posterior pair of lateral furrows are more a pair of moderately deep pits rather than furrows. To the posterior of these pits are the small, subquadrate basal lobes which are outlined on the adaxial margins by moderately deep and wide furrows which extend parallel to the axis of the glabella. The central one-third of the posterior glabellar lobe consists of a rounded ridge which extends all the way along the lobe increasing in height posteriorly.

As indicated above, the only good pygidial detail is seen in UT 92520, pl. 1, fig. 9, which is an incomplete, fairly well-preserved specimen. It occurs as two closely associated fragments which were probably originally separated by a scavenger (Jago 1974a).

PLATE 1

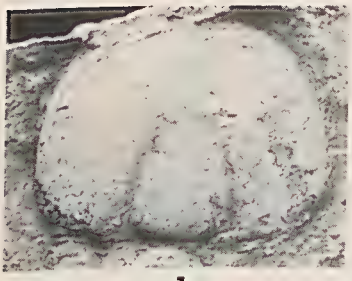
Figs. 1-4 — *Hypagnostus* cf. *brevifrons* (Angelin). 1, UT 92492, cephalon, W form, x12.8. 2, UT 92494, cephalon, intermediate distortion, x14.2. 3, UT 92493, pygidium, L form, x20. 4, UT 92495, pygidium, x10.5.

Fig. 5 — *Valenagnostus* sp. UT 92498, internal mould of partial pygidium, W form, x8.5.

Figs. 6-8 — *Pseudophalacroma(?)* sp. 6, UT 92502, internal mould of cephalon, x8.3. 7, UT 92501, internal mould of complete specimen, L form, x7. 8. UT 92500, complete specimen, L form, x13.

Figs. 9-15 — *Ptychagnostus (Goniagnostus)* sp. 9, UT 92520, internal mould of partially complete specimen with broken pygidium, x5. 10, UT 92523, internal mould of cephalon, x12.2. 11, UT 92521, external mould of cephalon figured in Fig. 10, x10.4. 12, UT 92524, internal mould of cephalon, x7. 13, UT 92525, internal mould of poorly preserved complete specimen, x9.5. 14, UT 92524, internal mould of cephalon, x8. 15, UT 92519, very poorly preserved pygidium, thorax and cephalic posterior, x14.5.

All specimens except that illustrated in Fig 5 come from Unit 13 of lower sedimentary sequence of Radfords Creek Group as exposed along main road to Gunns Plains. Fig. 5 comes from the timber track on west side of Sugarloaf Gorge, lower sedimentary sequence of Radfords Creek Group.



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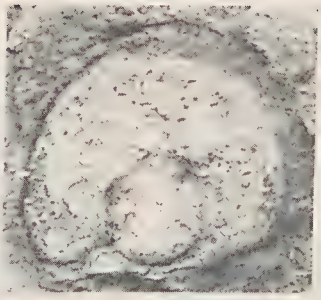

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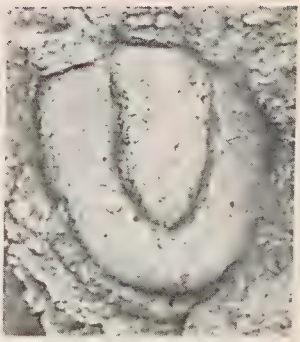

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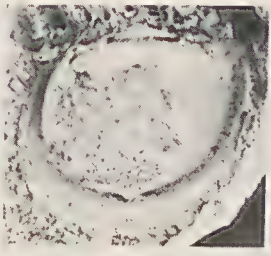

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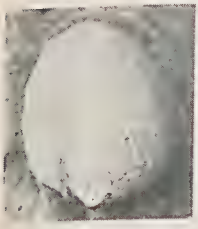

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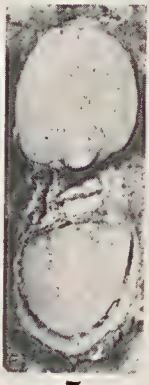

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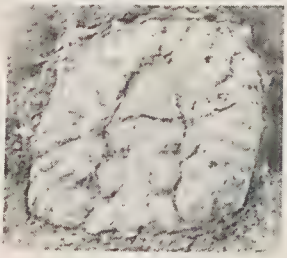

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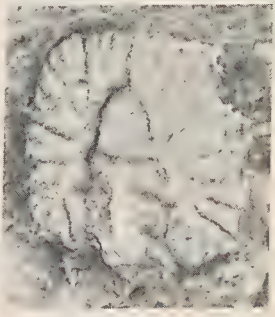

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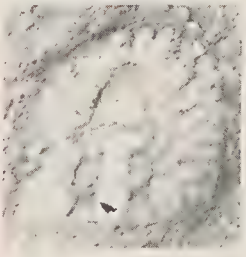

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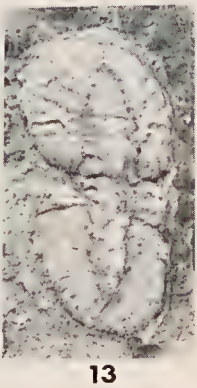

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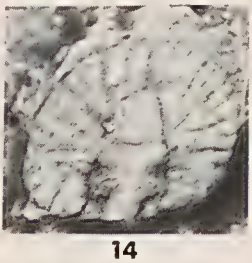

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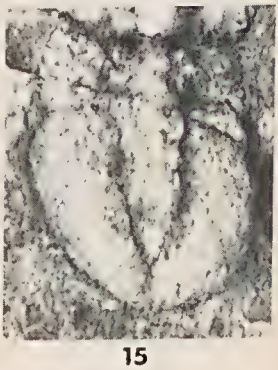

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PLATE 1

PLATE 2

Figs. 1-2 — *?Lejopyge laevigata* (Dalman). 1, UT 92527, internal mould of complete specimen, L form, x8.2. 2, UT 92528, pygidium, intermediate distortion, x9.

Figs. 3-8 — *Lejopyge laevigata armata* (Linnarsson). 3, UT 92529, cephalon and two thoracic segments, x6.7; 4, UT 92530, cephalon, x8.5; 5, UT 92532, pygidium, x8.8; 6, UT 92531, pygidium, x12.9; 7, UT 92533, posterior thoracic segment, x10.4; 8, UT 92534, pygidium (with an ?echinoderm plate), x8.2.

Figs. 9-12 — *Utagnostus(?) nevel* sp. nov. 9, UT 92607, cephalon and pygidium from same original animal, intermediate distortion, x20; 10, UT 92810, pygidium, intermediate distortion, x18.6; 11, UT 92605, holotype cephalon, W form, x24; 12, UT 92606, cephalon, intermediate distortion, x18.6.

Fig. 13 — *Diplagnostus* sp. UT 92621, cephalon, x18.5.

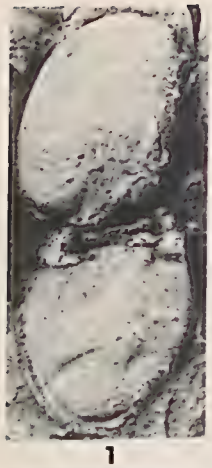
All specimens figured in Figs. 1-13 come from unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed on the main road to Gunns Plains, Sugarloaf Gorge.

Fig. 14 — *Aspidagnostus* sp. UT 92498, cephalon, W form, x16.

Figs. 15-17 — *Agnostascus* sp. Figs. 15 and 16, UT 92631, poorly preserved cephalon, 15, external mould, x5.8; 16, internal mould, x6.2. 17, UT 24542, pygidium, x7.3.

The specimens figured in Figs. 14-17 come from the lower sedimentary sequence of the Radfords Creek Group, old timber track, west side of Sugarloaf Gorge.

Fig. 18 — *Tasagnostus* sp., UT 92625, partially complete specimen, x5.4; locality, unit 15 of lower sedimentary sequence of Radfords Creek Group as exposed on the main road to Gunns Plains, Sugarloaf Gorge.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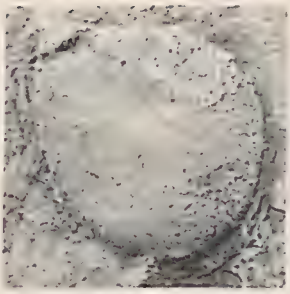
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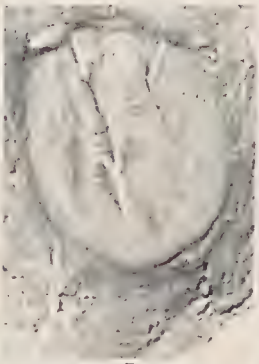
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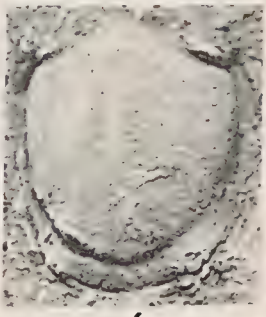
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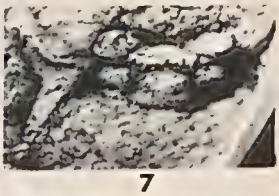
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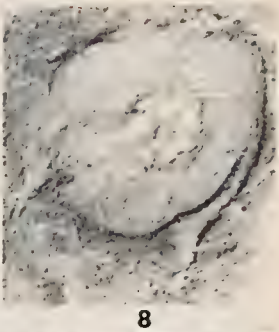
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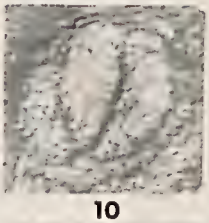
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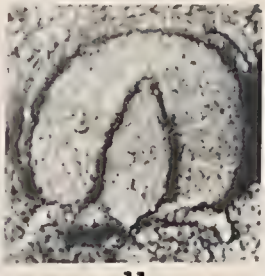
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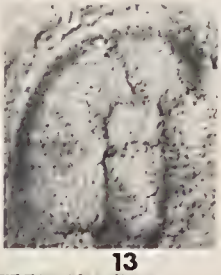
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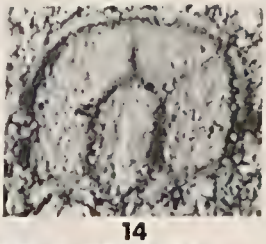
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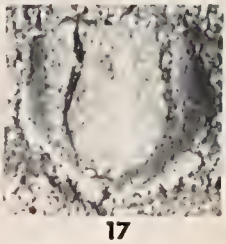
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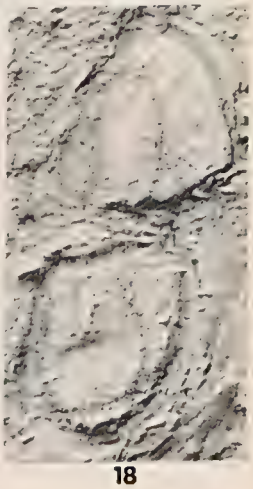
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PLATE 2

The border is composed of a narrow, shallow marginal furrow and a narrow, flat, elevated rim. The rim widens appreciably to two flat, short border spines. Anterior to the spines the pygidial margin is almost straight; the posterior margin of the pygidium between the spines is probably evenly curved. The shoulder furrows are narrow and shallow. The shoulders are not preserved well but appear to be reasonably wide. The articulating device is not visible. The pleural regions are smooth. There is a well developed post-axial median furrow. The pygidial axle is outlined by narrow, moderately deep furrows. Although the axle is never clearly preserved as a single unit, it appears to be quadrilobed and this species thus belongs in *Ptychagnostus (Goniagnostus)*. The length of the axis appears to be about 0.75 that of the pygidium. The two anterior lobes are short (sag.) and are outlined by distinct, narrow, shallow lateral furrows, the anterior pair of which run inwards and forwards from the axial furrows; the posterior pair of lateral furrows run inwards and backwards and meet around the posterior end of the prominent rounded ridge; this ridge extends along the centre of the two anterior axial lobes and may extend just over on to the third lobe. The ridge is just under one-third of the width of the axis.

Discussion: The Sugarloaf Gorge specimens of *Ptychagnostus (Goniagnostus)* are not well enough preserved to place in any particular species although they clearly belong to a single species of *Ptychagnostus (Goniagnostus)*. Thus, they are referred to *Ptychagnostus (Goniagnostus)* sp.

Occurrence: *Ptychagnostus (Goniagnostus)* sp. comes from unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road.

Genus *LEJOPYGE* Hawle and Corda, 1847

Synonymy: See Daily and Jago 1975

Type Species: *Battus laevigatus* Dalman 1828, p. 136.

Discussion: The taxonomic and biostratigraphic significance of the species and subspecies of *Lejopyge* have been discussed at length by Daily and Jago (1975).

Öpik (1961b, p. 94) differentiates between the cephala of *Pseudophalacroma dubium* and *Lejopyge* as follows:

(a) *dubium* has a more salient front than *Lejopyge*,

(b) *dubium* has considerably shorter residual dorsal furrows,

(c) the furrows around the basal lobes are much more effaced in *dubium* than in *Lejopyge*.

However, although (a) is valid, points (b) and (c) seem to be no longer valid with respect to the later published species *Lejopyge calva* Robison (1964, p. 521, pl. 83, figs. 1-4). In distorted specimens such as those from Sugarloaf Gorge, it is difficult to differentiate between *Pseudophalacroma* and *Lejopyge* on the basis of cephalic differences. However, the pygidia are distinct; the pygidial border of *Pseudophalacroma* is decidedly wider than that of *Lejopyge*; the marginal furrow of *Pseudophalacroma* is also deeper and more distinctly outlined; marginal spines are never present on *Pseudophalacroma*.

(?) *Lejopyge laevigata* (Dalman)
pl. 2, figs. 1, 2

Synonymy: See Palmer 1968, p. 28.

Material: About twelve specimens from the Sugarloaf Gorge section are provisionally assigned to *Lejopyge laevigata* (Dalman).

Measurements: UT 92527, complete internal mould, L form, total length, 6.8mm; cephalon, length, 3.5mm, width, 2.7mm; pygidium, length, 3.1mm, width, 2.8mm: UT 92528, pygidium, L form, length, 4.0mm, width, about 3.6mm.

Discussion: The usually poor preservation of fossils in the Sugarloaf Gorge section makes the differentiation of effaced agnostids difficult. *Lejopyge laevigata armata* (Linnarsson) is easily differentiated by means of its long spines. However, there appear to be two other groups of effaced agnostids present in the Sugarloaf Gorge section--one of which is probably *Lejopyge laevigata* (Dalman) and the other may be a species of *Pseudophalacroma* Pokrovskaya. As observed by Öpik (1961b, p. 94) when

discussing *Pseudophalacroma dubium* from Queensland, the cephala of *P. dubium* and *Lejopyge* are similar. The same would apply to other species of *Pseudophalacroma*. As noted above, two of Öpik's criteria for differentiating between the cephala of *dubium* and *Lejopyge* are invalid, and the third one (i.e., that *dubium* has a more salient front than *Lejopyge*) cannot be used in the Sugarloaf Gorge material.

The pygidia of *(?)Lejopyge laevigata* and the *Pseudophalacroma(?)* sp. from the Sugarloaf Gorge show about equal effacement. The differences are (a) the rim of *Pseudophalacroma(?)* sp. is wider than that of *(?)Lejopyge laevigata*, (b) the posterior of the acrolobe of *Pseudophalacroma(?)* sp. is sharper than that in *(?)Lejopyge laevigata*, and (c) the acrolobe in *Pseudophalacroma(?)* sp. has a "subtriangular" appearance. It should be noted that *(?)Lejopyge laevigata* from the Sugarloaf Gorge appears to be more effaced than the Swedish or Queensland examples of *L. laevigata;* it may be that the Sugarloaf Gorge form does not belong with *laevigata*.

Banks (1956, p. 185) refers to a record of Öpik (1951) in which Öpik records the occurrence of *Lejopyge laevigata* and *L. laevigata armata* from the same Sugarloaf Gorge location as the forms noted here as *(?)Lejopyge laevigata, Pseudophalacroma(?)* sp. and *L. laevigata armata*. The forms reported by Öpik as *L. laevigata* probably include both *(?)Lejopyge laevigata* and *Pseudophalacroma(?)* sp. as described here.
Occurrence: *(?)Lejopyge laevigata* (Dalman) comes from unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road.

Lejopyge laevigata armata (Linnarsson)
pl. 2, figs. 3-8

Agnostus laevigatus var. *armata* Linnarsson 1869, p. 82, pl. 2, figs. 58, 59.
Lejopyge laevigata armata (Linnarsson) Westergård 1946, p. 89, pl. 13, figs. 28-36; Öpik 1961b, p. 87, pl. 21, figs. 10a, b; pl. 22, figs. 1-4.
Lejopyge cos Öpik 1967, p. 93, pl. 57, figs. 5, 6; text fig. 20.
Material: About twenty specimens collected by the author were studied.
Measurements: UT 92529, cephalon, length, 4.5mm: UT 92530, cephalon, length, 4.7mm: UT 92531, pygidium, length, 2.8mm; width, 2.7mm: UT 92532, pygidium, length, 4.3mm, width, 3.8mm.
Discussion: There appears to be no essential difference between the Sugarloaf Gorge forms and the Swedish forms of *L. laevigata armata* figured by Westergård (1946, pl. 13, figs. 28-36). *L. laevigata armata* has been previously recorded from the Sugarloaf Gorge by Öpik (1951), Banks (1956, 1962) and Jago (1973, 1974b).
Occurrence: *Lejopyge laevigata armata* (Linnarsson) comes from unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road.

Family Clavagnostidae Howell, 1937
Subfamily Aspidagnostinae Pokrovskaya, 1960
Genus *ASPIDAGNOSTUS* Whitehouse, 1936

Synonymy: See Jago 1976.
Type Species: *Aspidagnostus parmatus* Whitehouse 1936, p. 105, pl. 9, fig. 5 only.
Diagnosis: See Öpik 1967, p. 116 and comment by Jago (1976).

Aspidagnostus sp.
pl. 2, fig. 14

One poorly preserved partial cephalon, UT 92498, is known. It has a similar appearance to the cephalon of *Aspidagnostus* sp. from St. Valentines Peak (Jago 1976), but without better preservation no firm assignation can be made. It is referred to *Aspidagnostus* sp.
Occurrence: *Aspidagnostus* sp. comes from the lowest fauna exposed along the old timber track on the west side of Sugarloaf Gorge, lat. 41°15.4'S, long. 146°04.2'E.

Family Diplagnostidae Whitehouse, 1936
Subfamily Diplagnostinae Whitehouse, 1936
Genus *DIPLAGNOSTUS* Jaekel, 1909

Synonymy: See Jago 1976
Type Species: *Agnostus planicauda* Tullberg, 1880 (*non* Angelin, 1851).
Diagnosis: See Öpik 1961b, p. 69

Diplagnostus sp.
pl. 2, fig. 13

Material: Only one poorly preserved cephalon UT 92621 is available for study. Both the internal and external moulds are present although only about half the external mould is preserved.
Measurements: On external mould, exposed length, 1.9mm; on internal mould, length, 1.9mm; width, 1.9mm.
Description: The strongly convex cephalon is about as wide as long. The border is composed of a wide, shallow marginal furrow and a moderately wide, elevated rim. The border narrows to the posterior. The area in front of the glabella is not clearly preserved, but there appears to be a faint preglabellar median furrow at least in the region immediately in front of the glabella. The cheeks seem to be slightly scrobiculate. The basal lobes are small and simple. The glabella is outlined by moderately wide and deep, almost parallel furrows. Just to the posterior of the transverse glabellar furrow, the glabella widens slightly.

The transverse glabellar furrow is not very clearly preserved, but it appears to be shallow, moderately wide, and arched slightly forward. The anterior glabellar lobe is almost square. There is a small median sulcus at the front of the anterior glabellar lobe. At the transverse glabellar furrow the glabella is just under 0.3 the width of the cephalon. The glabellar length is about 0.65 that of the cephalon. The anterior glabellar lobe has a length about 0.3 that of the glabella. No details of the posterior glabellar lobe are visible although the glabellar rear is subangular (seen on internal mould).
Discussion: There is only one cephalon of *Diplagnostus* from Sugarloaf Gorge. This specimen does not allow a detailed comparison with described species of *Diplagnostus*. It is referred to here as *Diplagnostus* sp.
Occurrence: *Diplagnostus* sp. comes from unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road.

Subfamily Oidalagnostinae Öpik, 1967
Genus *TASAGNOSTUS* Jago, 1976

Tasagnostus Jago, 1976
Type Species: *Tasagnostus debori* Jago, 1976
Diagnosis: See Jago 1976

Tasagnostus sp.
pl. 2, fig. 18

A single specimen UT 92625 comprising a poorly preserved almost complete agnostid is known from the upper part of unit 15 along the road to Gunns Plains. The wide borders, the elongated node on the anterior of the posterior glabellar lobe, the zonate pygidium and the postero-centrally placed transverse pygidial axial furrow indicate that this specimen belongs in *Tasagnostus*.

It differs from both *T. debori* and *T. compani* in that the posterior pygidial axial lobe is more expanded than in either of these species. Consequently, the width of the posterior part of the pleural areas is much smaller than in either *debori* or *compani*. However, the specimen is not well enough preserved to allow the erection of a new species, and it is termed *Tasagnostus* sp.
Occurrence: *Tasagnostus* sp. comes from unit 15 of the lower sedimentary sequence of

the Radfords Creek Group as exposed along the Gunns Plains Road.

Subfamily Unknown
Genus *UTAGNOSTUS* Robison 1964

Utagnostus Robison 1964, p. 532, Jago 1976.
Type Species: *Utagnostus trispinulus* Robison 1964, p. 533, pl. 82, figs. 21-28.
Diagnosis: See Robison 1964, p. 532.

Utagnostus(?) nevel sp. nov.
pl. 2, figs. 9-12

Material: Two moderately well-preserved cephala (UT 92605, UT 92606), one poorly preserved specimen (UT 92607) which has an associated cephalon and pygidium from the one animal, two poorly preserved cephala (UT 92608, UT 92609) and a poorly preserved pygidium (UT 92610) are available for description.
Selection of Holotype: The best preserved cephalon, UT 92605 (pl. 16, fig. 7) is selected as the holotype.
Diagnosis: The cephalon of this small agnostid has a narrow border with a moderately wide, flat rim and long posterolateral spines. There is no preglabellar median furrow. The basal lobes are small and simple. A vestigial bilobation of the apparently monolobed glabella is outlined by a distinct narrowing of the glabella towards the anterior. The pygidium has a narrow border with two short border spines. The posterior border extends slightly forward at its centre to meet the narrow pointed axis.
Measurements: UT 92605, cephalon, W form, length, 1.2mm, width, 1.3mm; UT 92607, cephalon, intermediate distortion, length, 1.1mm, width about 1.1mm; pygidium, length, 1.1mm, width, 1.0mm.
Description: The small, moderately convex cephalon is about as wide as long. There is a narrow, shallow, marginal furrow and a moderately wide, flat rim. A pair of thick, moderately long posterolateral spines arise from wide bases. The cheeks appear to be smooth. There is no preglabellar furrow. The glabella is outlined by moderately wide and deep furrows; it has a length about two-thirds that of the cephalon. Between the tips of the short, small, simple basal lobes and about the midpoint of the glabella, the glabella has parallel sides. A vestigial bilobation of the apparently monolobed glabella is outlined by a sharp narrowing of the glabella towards the anterior. At the same point the glabella on some specimens appears to have a faint transverse glabellar furrow, but this is probably due to the effects of distortion. No other glabellar details can be seen except that the glabellar rear is angular.

No pygidium is very well or completely preserved. The markedly convex pygidium is about as wide as long. The marginal furrow is narrow and shallow. There are two short border spines between which the posterior rim is wider than the narrow lateral rims. The posterior border extends slightly forward at its centre to meet the narrow pointed axis, which is outlined by moderately wide and deep furrows. The axis has a length about 0.8 that of the pygidium. The pleural fields are smooth. No axial details can be clearly seen. The articulating device is never well preserved, but the articulating furrow has a deep pit at either end.

Discussion: This species was referred to in Jago (1973, p. 409) as cf. *Clavagnostus* sp. It is here questionably included in *Utagnostus*. It is similar to *U. neglecta* in that it has an apparently monolobed glabella and large cephalic spines. However, the pygidial axis of *nevel* is shorter and narrower than in any known species of *Utagnostus*. The pygidium of *Utagnostus* is trispinose, but the preservation of *nevel* is too poor to determine if its pygidium is trispinose. *Utagnostus(?) nevel* differs from *U. neglecta* in that it has an angular glabellar rear and shorter pygidial spines. The pygidial axis of *U(?) nevel* is narrower and is more pointed than that of *U. neglecta*.

The cephalon of *U(?) nevel* is similar to that of *U. trispinulus* Robison (1964, pl. 82, figs. 21-24) except that the glabella of *U. trispinulus* has a distinct transverse

glabellar furrow. However, the pygidium of *trispinulus* has a wide, somewhat expanded, axis and a trispinose margin.
Occurrence: *Utagnostus(?) nevel* sp. nov. comes from unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road.

Genus *AGNOSTASCUS* Öpik, 1967

Agnostascus Öpik,1967, p. 147.
Type Species: *Agnostascus gravis* Öpik,1967, p. 147, pl. 61, figs. 1-4, text fig. 38.
Diagnosis: See Öpik 1967, p. 147.

Agnostascus sp.
pl. 2, figs. 15-17

Material: One poorly preserved, partial cephalon (UT 92631) and one poorly preserved pygidium (UT 24542) are available. The pygidium has a length of 3.3mm (excluding the articulating half-ring) and a width of 3.3mm.
Description: The cephalon has a constricted acrolobe. At the anterior the rim is narrow and elevated and the marginal furrow is of moderate width. Both narrow to the posterior. There is a shallow transverse glabellar furrow. The anterior glabellar lobe has a length about 0.3 that of the glabella. There is probably a preglabellar median furrow. There is a node placed well forward on the posterior glabellar lobe. The basal lobes are small. No other glabellar details can be seen.

The border details of the strongly convex pygidium are not entirely clear. There is a narrow to moderately wide marginal furrow and a narrow rim. The preservation is such that border spines, if present, cannot be seen. The acrolobe is constricted. The wide trilobed axis has a broadly rounded rear and extends the full length of the acrolobe. The posterior lobe is slightly expanded. The axis is slightly constricted at the second axial lobe. There are no transverse axial furrows; the axial furrows are narrow and deep. There is a low, elongated node on the second lobe.
Discussion: The preservation of *Agnostascus* sp. is too poor to assign it to either an existing species or to a new species. However, it is quite similar to *A. gravis* Öpik as far as can be seen. The pygidial axis of the Tasmanian form is a little wider than that of *A. gravis*.
Occurrence: *Agnostascus* sp. is known from the lower sedimentary succession of the Radfords Creek Group as exposed on an old timber track along the west side of Sugarloaf Gorge.

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INVERTEBRATE ANIMALS, INCLUDING TYPE SPECIMENS, TRANSFERRED FROM THE UNIVERSITY OF TASMANIA TO THE TASMANIAN MUSEUM

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ABSTRACT

Collections of Tasmanian invertebrates, formerly housed in the Department of Zoology, University of Tasmania, have been presented to the Tasmanian Museum. They include type specimens of Turbellaria, Trematoda, Cestoda, Hirudinea and Ascothoracida and examples of Hydroidea and Psocoptera.

INTRODUCTION

In June 1974 the Department of Zoology, University of Tasmania, presented to the Tasmanian Museum a collection of microscope slides prepared by former members of the department. Many of these slides bear type specimens. Their transfer was arranged by Dr. J.L. Hickman who also donated to the museum the types of his own species of Cestoda and Ascothoracida which were previously lodged in the Department of Zoology. Another donation by this department, which was arranged by Dr. Hickman in September 1975 included type specimens of Hirudinea.

The type material received is listed in a table and a brief account is given of other parts of the collections. All of the animals mentioned were found in Tasmania.

In cases where the holotype and paratype(s) are held, the first museum registration number listed for the species has been assigned to the holotype; the same applies to lectotype and paralectotypes. One registration number may represent more than one microscope slide, as in the case of serial sections where one number refers to all of the slides in a series.

TYPE MATERIAL

Abbreviations
H = holotype; A = allotype; P = paratype(s); S = syntype(s);
L = lectotype; PL = paralectotypes.

	Species	Types	Registration Numbers
TURBELLARIA	*Acholades asteris* Hickman & Olsen, 1955	H & P	K525 - K530
"	*Avagina vivipara* Hickman, 1956	H & P	K523 - K524
"	*Marcusella pallida* Hickman, 1956	H & P	K538 - K539
"	*Notothrix inquilina* Hickman, 1955(b)	H & P	K531 - K533
"	*Ozametra striata* Hickman, 1955(b)	H & P	K534 - K537
"	*Syndesmis punicea* Hickman, 1956	H & P	K540 - K547
TREMATODA	*Bivesicula australis* Crowcroft, 1947(c) (see note 1)	S	K626 - K628
"	*Coitocaecum anaspidis* Hickman, 1934	S	K548 - K555
"	*Coitocaecum parvum* Crowcroft, 1945	S	K565 - K573
"	*Copiatestes thyrsitae* Crowcroft, 1948	S	K629 - K637

Invertebrate animals transferred to the Tasmanian Museum

	Species	Types	Registration Numbers
TREMATODA	*Gnathomyzon insolens* Crowcroft, 1945	S	K574 - K580
"	*Helicometra neosebastodis* Crowcroft, 1947(a) (see note 2)	S	K581 - K583
"	*Hemiperina manteri* Crowcroft, 1947(c)	S	K618 - K625
"	*Maritrema ornithorhynchi* Hickman, 1955(a)	H & P	K556 - K564
"	*Opecoelus tasmanicus* Crowcroft, 1947(c)	(S	K602 - K611
	(see note 3)	(S?	K612 - K613
"	*Parahemiurus lovettiae* Crowcroft, 1947(c) (see note 4)	S	K615 - K617
"	*Sterrhurus macrorchis* Crowcroft, 1946	S	K597 - K601
"	*Telorhynchus arripidis* Crowcroft, 1947(a) (see note 5)	S?	K584 - K596
CESTODA	*Anthobothrium hickmani* Crowcroft, 1947(b)	S	K675 - K682
"	*Barietta criniae criniae* Hickman, 1960	H & P	K710 - K712
"	*Barietta criniae minor* Hickman, 1960	P	K713 - K717
"	*Nematotaenia hylae* Hickman, 1960	H & P	K705 - K709
"	*Oochoristica nyctophili* Hickman, 1954	H & P	K701 - K704
"	*Oochoristica vacuolata* Hickman, 1954	H & P	K683 - K700
HIRUDINEA	*Austrobdella bilobata* Ingram, 1957	S	K718 - K721
"	*Glossiphonia tasmaniensis* Ingram, 1957	S	K732 - K735
"	*Ichthyobdella platycephali* Ingram, 1957	H & P	K731 , K792
"	*Philaemon grandis* Ingram, 1957	H	K742
"	*Placobdella bdellae* Ingram, 1957	S	K737 - K740
"	*Trachelobdella leptocephali* Ingram, 1957 (see note 6)	L & PL	K773 - K778
ASCOTHORACIDA	*Dendrogaster tasmaniensis* Hickman, 1959	H,A,P	G1586 - G1600

NOTES ON TYPE MATERIAL

(1) *Bivesicula australis* Crowcroft

Slide K626 is labelled "Type". However, the specimen thereon is a syntype and not a holotype because two slides of *B. australis*, each labelled "Co-type", are lodged in the Australian Museum, Sydney (Reg. nos. W3509, W3510).

(2) *Helicometra neosebastodis* Crowcroft

Sekerak and Arai (1974, p. 726) have regarded *H. neosebastodis* as a synonym of *H. tenuifolia* Woolcock, 1935.

(3) *Opecoelus tasmanicus* Crowcroft

The status of two slides of *O. tasmanicus* (K612, K613) is uncertain. They may not belong to the syntype series as their labels differ, in handwriting and content, from those of the other slides of whole mounts of this species.

(4) *Parahemiurus* species

The Australian Museum has ten slides of Crowcroft's species of Trematoda, each labelled "Co-type". One of these (Reg. no. W3515) was labelled *"Parahemiurus australis* Crowcroft ex *Lovettia sealii"*. However, the species which Crowcroft (1947c, p.13) established from trematodes found in *Lovettia sealii* Johnston is *P. lovettiae*. The

author of *P.australis* is Woolcock and its host is *Physiculus barbatus* Günther (see Crowcroft, 1947c, p.16).

The collection given to the Tasmanian Museum by the University of Tasmania includes two slides of whole mounts (K614, K615) which were labelled as *"Parahemiurus lovettiae* Crowcroft". These three slides of *Parahemiurus* have been examined by Dr. Hickman who has confirmed that their labels were incorrect. He has identified their specimens as follows:-

Australian Museum: no. W3515 bears four examples of *P.lovettiae* Crowcroft (syntypes).

Tasmanian Museum: no. K614 bears three examples of *P.australis* Woolcock.

Tasmanian Museum: no. K615 bears two specimens of *P.lovettiae* Crowcroft (syntypes) and one of *Telorhynchus* sp.

(5) *Telorhynchus arripidis* Crowcroft

One slide of *T.arripidis*, labelled as "Co-type", is held by the Australian Museum (Reg. no. W3511). Presumably Crowcroft's other examples of this species represent the rest of the syntype series. However, the relevant slides (K584 - K596) were not originally labelled with a specific name; their specimens have been identified as *T.arripidis* by Dr. Hickman.

(6) *Trachelobdella leptocephali* Ingram

When Ingram's microscope slides of Hirudinea were presented to the Tasmanian Museum in 1974, the gift theoretically included her slides of *T.leptocephali* which then had the status of syntypes. In fact the latter were absent on loan and were not actually received by the museum. It has since been established that these slides have been mislaid by the borrower.

Therefore, in September 1975, Mrs. D.M. Banks (née Ingram) examined the remainder of her type series of *T.leptocephali* which was still held by the Department of Zoology. She chose one whole specimen to be designated as a lectotype and five specimens to be named as paralectotypes. These animals were then transferred to the Tasmanian Museum, together with other whole specimens from Ingram's collection. The missing slides, if they are found, will have the status of paralectotypes.

OTHER MATERIAL

In addition to the type specimens listed, the collections received from the University of Tasmania contain the following material on which published studies have been based. (Registration numbers are given in parentheses).

HYDROIDEA

Hydroids reviewed by Hodgson (1950), including examples of *Halecium fragile* Hodgson (K444, K445).

TREMATODA

Known species of trematodes studied by Crowcroft (1947c, 1950).

HIRUDINEA

Hirudinea described by Ingram (1957) including additional specimens, not designated as type material, of three of her own species:- *Austrobdella bilobata* (K722-K730, K786-K791), *Glossiphonia tasmaniensis* (K736) and *Placobdella bdellae* (K741, K784).

PSOCOPTERA

Slides bearing separate parts of psocids studied by Edwards (1950), including examples of his own species:- *Caecilius quercus* (F301), *Clematostigma tardipes* (F286), *Interpsocus brunneus* (F299), *Peripsocus eucalypti* (F297), *P.macropterus* (F298), *Philotarsus greyi* (F295) and *Trichopsocus australis* (F296).

The holotypes and allotypes of Edwards' species are lodged in the Australian Museum. It is possible that the author's slides of these species, now held by the Tasmanian Museum, represent paratype material.

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The gifts by the Department of Zoology, University of Tasmania, to the Tasmanian Museum of scientifically valuable collections are greatly appreciated. Personal thanks are due to Dr. J.L. Hickman, Senior Lecturer in Zoology, for his initiative in arranging the transfers and for his considerable help in listing and checking the status of the material before its presentation. Dr. Crowcroft's type slides in the Australian Museum were examined with the permission of Dr. P.A. Hutchings, who is thanked for her assistance.

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APPENDIX

In August, 1976, Professor V.V. Hickman presented to the Tasmanian Museum the microscope slides which bear his type specimens of Turbellaria : Temnocephalidea

Species	Types	Registration Numbers
Temnocephala cita Hickman, 1967	S	K827 - K828
Temnocephala fulva Hickman, 1967	H & P	K829 - K830
Temnocephala pygmaea Hickman, 1967	H & P	K831 - K833

REFERENCE

HICKMAN, V.V., 1967 : Tasmanian Temnocephalidea. *Pap. Proc. R. Soc. Tasm.*, 101, 227-50, pl. I.

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STRUCTURE AND METAMORPHISM OF THE Mc PARTLAN PASS - SENTINELS AREA

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(with one table, four text-figures and four plates)

ABSTRACT

Low metamorphic grade Precambrian quartzites and phyllites of the Mc. Partlan Pass - Sentinels area have been subjected to polyphase deformation and polyphase metamorphism. The earliest recognizable folds are tight to isoclinal and they have a penetrative foliation, with syntectonic mineral growth parallel to their axial surface. F_2 folds, which are also tight to isoclinal and nearly coplanar with F_1, have an associated S_2 crenulation cleavage, with syntectonic mineral growth. The dominant folds in this area are of the third generation and they control the orientation of earlier structures. F_3 are tight to close, upright folds in phyllites, and are of more open style in quartzites. They have a moderate to steep north-westerly plunge. The S_3 cleavage may be a crenulation cleavage, a fracture cleavage, or a more isotropic foliation. D_4 structures occur sporadically throughout the area. Events D_1 to D_4 are of probable Precambrian age. The latest structures include two distinct sets of kink bands, which may have been produced during a Palaeozoic orogeny.

INTRODUCTION

This report is a summary of a B.Sc. Honours thesis submitted to the Geology Department, University of Tasmania in 1973. The aim of this work was to establish a structural and metamorphic sequence within complexly folded quartzites and phyllites in the Mc. Partlan Pass - Sentinels area of south-western Tasmania. The area under consideration is bounded by: longitude 146°09'E and 146°15'E and latitude 42°50'S and 42°54'S. Convenient access is provided by the Gordon River Road.

The area is mountainous with steep, sharp ridges separated by V-shaped valleys, or wide, flat, marshes. The morphology is directly related to the susceptibility of the underlying rocks to weathering and erosion. Topographic highs are formed in quartzites and topographic lows are in phyllite and micaceous quartzite. Poor outcrop of the latter rock types largely restricts their study to road cuttings.

The notation used herein to describe structures, or events and their temporal relationship is: D_n refers to deformation event n; F_n indicates folds associated with event D_n; and S_n and L_n refer, respectively, to any surface, or lineation, related to D_n. S_o denotes the original bedding surface.

ROCK TYPES

The Precambrian metamorphic assemblage has been broadly divided into four major rock types: quartzites, micaceous quartzites: phyllites and a metaconglomerate unit. Two main types of quartzites can be distinguished. The first is a well-layered coarse-to medium-grained, saccharoidal orthoquartzite, which occurs in relatively thick units (approximately 500 metres) on the northern and western flanks of the Sentinels. The other is a flaggy, laminated variety which occurs in thinner units (maximum thickness about 30 metres) and crops out on the tops and flanks of the ridges north and south of Mc. Partlan Pass.

The micaceous quartzites are composed dominantly of quartz with varying amounts

of muscovite (5%-30%) and locally chlorite as a minor component. They grade into purer quartzite at one extreme and into phyllite at the other extreme. The phyllites are mica rich, fine-to very fine-grained, grey to black,or light green rocks. They are extremely fissile. Some varieties are graphitic.

The metaconglomerate unit consist of a sequence of poorly-sorted metaconglomerates, micaceous quartzites and phyllites, which may contain pebbly bands and isolated pebbles. They occupy an area to the immediate north of the Sentinels (fig. 1) Their contact with the quartzite and micaceous quartzite of the Sentinels is not exposed, and is an uncomformity.

FIRST GENERATION STRUCTURES

F_1 Folds

The earliest recognizable structures in the area include folds with an earlier form surface, which in some cases can be shown to be bedding (S_0), from the presence of folded cross-bedding, and elsewhere is assumed to be S_0. Minor fold closures of the first generation are not commonly observed in the area as a whole. They are most easily recognized in purer quartzites, where overprinting by later structures is minimal. First folds are usually moderately to steeply inclined and the trend of their axial surface is dominantly controlled by major folds of the third generation. The plunge of F_1 hinges is highly variable, due to the combined effects of several phases of deformation. However, they commonly plunge moderate to steep SW.

F_1 folds are tight to isoclinal. Thicker psammitic layers have rounded hinge zones and are often flattened parallel in style. Thinner units have greater thickening in the hinge zone. In a folded sequence of layers with variable thickness there is usually a disharmonic relationship between the layers, with the thinner layers being more complexly folded. Where there is a considerable competence difference between folded layers, the limbs of the more competent layers are often attenuated, leading to boudinage.

Analysis of the vergence of minor F_1 has revealed only one major F_1 closure in the area, which occurs at the eastern end of the Sentinels. However, studies of this kind are hampered by the fact that minor F_1 folds are usually long-limbed isoclines, which give no indication of vergence, and other unrecognized major closures may be present.

The S_1 Foliation

S_1 is an axial surface foliation to folds of the first generation. It is well developed throughout the area, except in the thick quartzite units of the Sentinels, where it only occurs sporadically. The S_1 foliation is parallel to the boundaries between major lithological units and is probably parallel to the original bedding. However, S_1 is not a "bedding-foliation" as can be demonstrated by local survivals of folded and disrupted fragments of earlier layers (S_0). The near parallelism of S_1 and S_0 is due to the isoclinal nature of F_1 folds.

The expression of S_1 varies for different rock types. In flaggy laminated quartzites S_1 metamorphically differentiated layering consists of layers rich in quartz (1mm ro 4mm thick) separated by thin films of mica. In micaceous quartzites the differentiated mica layers are thicker (up to 4mm thick). Quartz-rich layers have a well developed mortar texture (plate 1a). In phyllites S_1 is a very penetrative slaty cleavage in which individual differentiated layers are not visible in hand specimen. The foliation is defined by the strong preferred alignment of tiny, interwoven mica flakes and fibres, with small, thin, elongate lenses and ribbons of quartz.

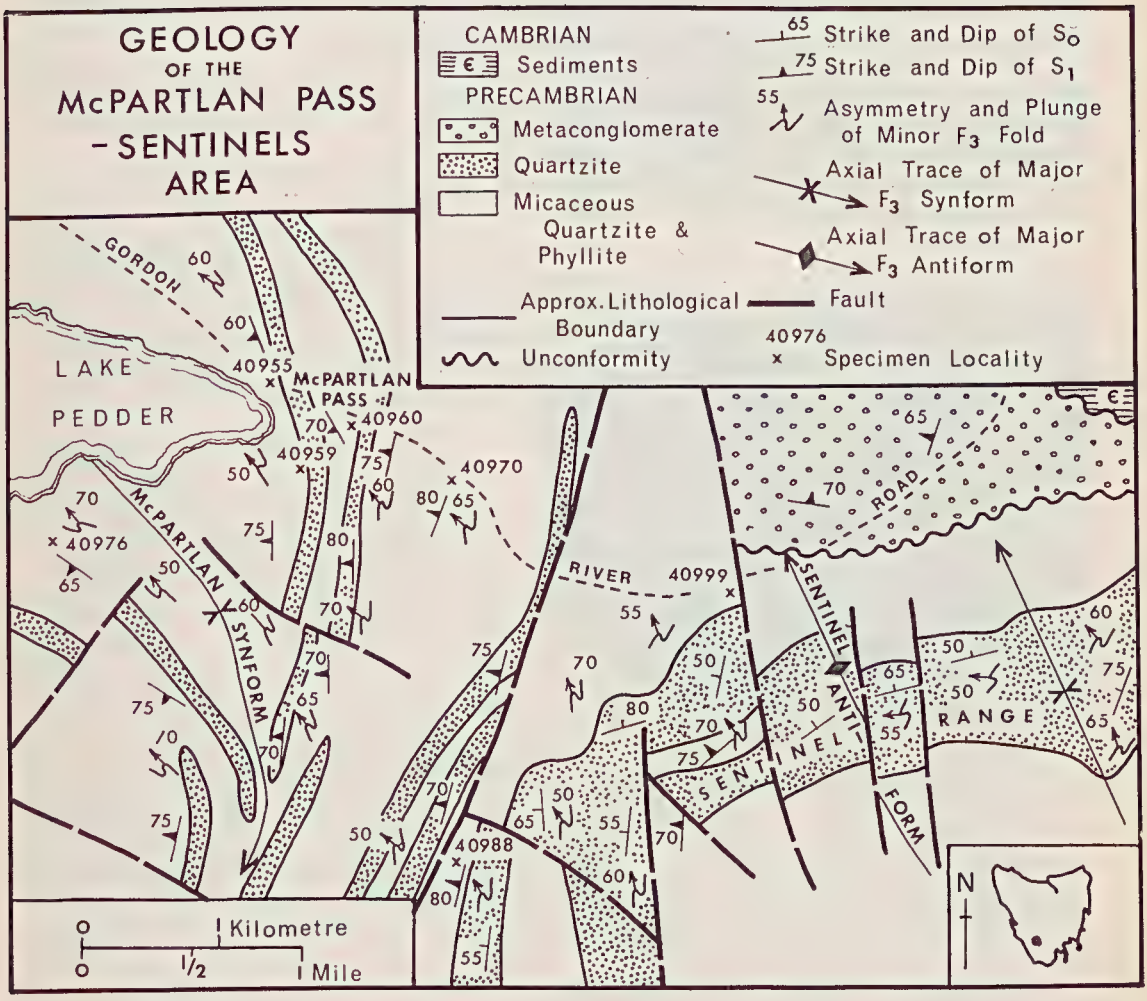

FIG. 1.- Rock types and structural elements of the McPartlan Pass - Sentinels area.

Progressive development of S_1 in quartzites

In the less deformed orthoquartzites of the Sentinels the S_1 surface, or later foliations, may be entirely absent. In this case the original sedimentary fabric, consisting of nearly spheroidal well-rounded, interpenetrating quartz grains with authigenic quartz overgrowths, is preserved intact. Deformation of this fabric dur-

ing D_1 produced elongate ellipsoidal quartz grains the dimensional preferred orientation of which defines S_1. At this early stage of foliation development, the quartz grains are invariably undulose, they are commonly fractured and are occasionally disrupted. However, unlike the quartzites in which S_1 is intensely developed, these quartz grains show little or no granulation. Also, despite elongation of the grains, the authigenic quartz overgrowths are still preserved. Where S_1 is observable as a weak foliation microscopically, it is not usually visible in hand-specimen, even if a weak mica foliation is present. The slightly elongate quartz grains may be wrapped by a thin mica film, but at this stage the mica foliation is only coarsely anastomosing. As the quartz grains become more elongate the mica films become more finely anastomosing so that eventually they do define a good mesoscopic foliation.

In quartzites, of the same composition, from the ridges south of Mc. Partlan Pass the continuing sequence of progressively more intense S_1 development can be traced. The quartz grains become more elongate with strong undulosity and often deformation lamellae are present. They develop small "beards" of fibrous quartz, as well as granulated grain margins and a more disrupted appearance (plate 1). As S_1 becomes more intense in development the older grains are almost completely broken down and consist of isolated, highly deformed remnants set in matrix of finer-grained, granulated, re-crystallized quartz (plate 2). Thus the progressive development of S_1 in quartzites involves the conversion of a saccharoidal texture into a mortar texture.

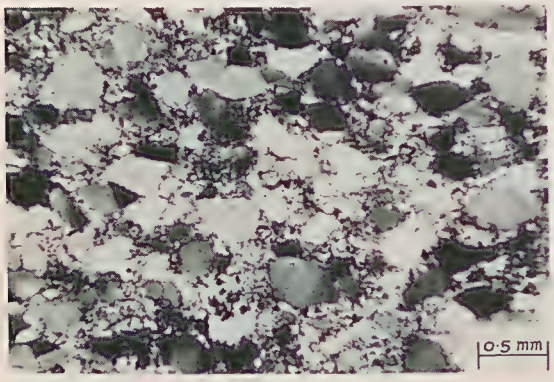

PLATE 1.- Quartzite with moderate S_1 development. The elongate quartz grains have sutured and granulated margins and fibrous quartz beards. They are surrounded by fine-grained, granulated quartz.

SECOND GENERATION STRUCTURES

Folds of the second generation are tight to isoclinal. They have many features in common with F_1 folds and are often difficult to distinguish from the latter in the field. Minor F_2 closures are somewhat sporadic in occurrence, but they are locally abundant around Mc.Partlan Pass. In phyllites F_2 closures are often obscured by an intense generated S_2 surface, and by over-printing of later cleavages, mainly S_3. Since their orientation depends on third and later generation folds, F_2 folds can be upright, steeply inclined, or reclined and their axial surfaces vary in strike from WNW to NNE with corresponding southerly to westerly dips. F_2 hinges are also variable in orientation, but they commonly plunge steeply to moderately WSW. Minor second folds do not usually give any sense of vergence, but where this is present they are, in all cases, asymmetric folds with an "S profile when viewed to the WSW down the axis. No major F_2 closures have been found in the area mapped.

In quartzites F_2 folds are distinguished from F_1 by microscopic analysis of the hinge area. Second folds have a penetrative, lenticular S_1 foliation as their form surface and this may be partially, or totally obliterated by a fairly penetrative, generated S_2 foliation, which cuts across S_1 at a high angle in the fold core. In phyllites and micaceous quartzites F_2 folds have a generated S_2 crenulation cleavage, which is at high angle to S_1 in the F_2 fold core (plate 3). Away from F_2 core zones, the S_2 surface can be observed as a spaced (1mm to 1cm) crenulation cleavage, at a low angle (15° to 20°) oblique to S_1. This produces a characteristic lenticular, diamond

pattern in the rocks. However, in most phyllites, and in some micaceous quartzites, S_2 has been refracted into near alignment with S_1 and merely serves to accentuate the earlier penetrative foliation.

Lineations produced during D_2 include an L_2 crumple lineation, associated with S_2 crenulations, and an intersection lineation between S_1 and S_2. L_2 lineations are usually parallel to local F_2 hinges. These lineations are invarably cross-cut by a later, fine, crumple lineation (L_3). Micas which grow along the S_2 foliation surface are often crenulated or crinkled by the later S_3 cleavage (plate 3).

PLATE 2.- Strongly annealed quartz grains in a quartzite with an intense S_1 foliation developed.

THIRD GENERATION STRUCTURES

F_3 Folds

The third deformation event produced the dominant folds of this area. These folds exist on all scales, from microscopic crenulation up to macroscopic folds hundreds of metres in wavelength, and they control the orientation of the earlier surfaces, S_o, S_1 and S_2. Both F_1 and F_2 folds have been refolded by F_3 and the superposed interference patterns are Type 3 of Ramsay (1962).

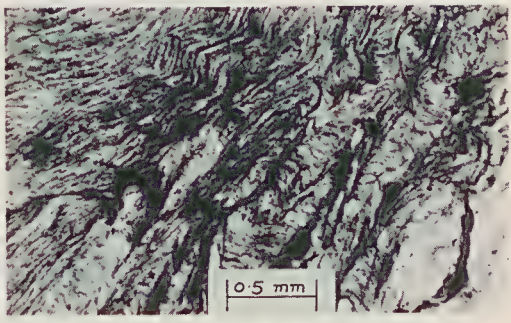

PLATE 3.- Differentiated S_2 crenulation cleavage from an F_2 fold core in phyllite. Twisted relics of S_1 exist between bands of S_2 mica. The latter have in turn been deformed by the development of S_3 crenulations.

Minor F_3 folds are generally steeply inclined to upright, with axial surfaces that strike NW and dip steeply SW. Their hinges usually plunge moderately to steeply WNW. The fold style is largely governed by lithology. In the well-laminated micaceous quartzites minor F_3 folds are often kink like, open to tight folds, with rounded, and sometimes angular, hinge zones. In the more competent, thickly-layered quartzites F_3 folds are usually open, parallel in style, except in areas of more intense deformation, such as the eastern end of the Sentinels, where they commonly have a flattened parallel profile. Where quartzite is inter-layered with less competent pelitic layers, the overall geometry is that of similar folds.

Folds of the types described above have been reported by Powell (1969) from the Gordon River Damsite, Bowen and Maclean (1971) from the Davey River and Boulter (1974) from the Frankland and Wilmot Ranges. Powell, Bowen and Maclean regard them as second generation structures, but Boulter and the present author regard them as third generation structures.

By analysis of the vergence of minor asymmetric F_3 folds (fig. 1) two major, third fold closures, each of which is composed of folds of various orders, have been determ-

ined. These are the Mc. Partlan Synform (statistical axis 77° to 260°) and the Sentinels Antiform (statistical axis 70° to 331°). Contoured stereoplots for each of these structures are given in figures 2a and 2b. Both major folds are more or less cylindrical and the difference in their statistical axes may be due to rotation about a major fault which separates them. Despite the overall near cylindrical nature of the major third folds, some minor F_3 folds show marked variability of plunge.

S_3 Cleavage

Associated with third folds is an axial surfaces cleavage, S_3, which varies in type according to: the rock type; the nature of the pre-existing surface; and the amount of local strain. In the quartzites of the Sentinels S_3 is often the first foliation to affect the original bedding, and its development varies from a weak, to fairly penetrative, lenticular foliation, or in some cases a distinct, spaced (1cm to

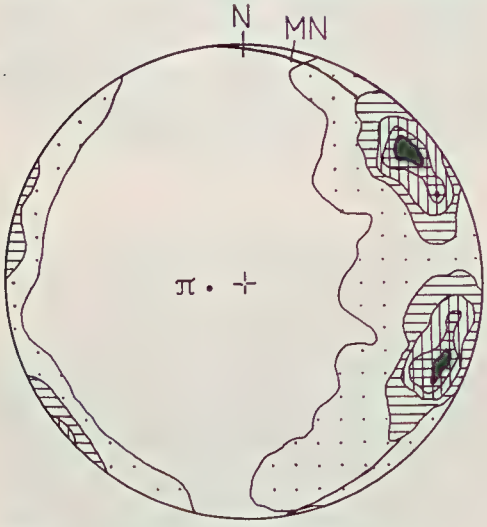

FIG. 2a - A contoured, equal-area, stereographic projection of the Mc. Partlan Synform using 215 poles to S_1. The contours are at 0 - 3 - 6 - 9 - 12%. The π axis is 77° to 260°.

FIG. 2b.- A contoured, equal-area, stereographic projection of the Sentinels Antiform using 220 poles to S_1 and S_0. The contours are at 0 - 1 - 3 - 5 - 7%. The π axis is 77° to 331°.

3cm) fracture. In micaceous quartzites and phyllites, S_3 is a crenulation cleavage, with associated L_3 crumple lineations. The nature of the crenulation cleavage is somewhat variable. One type consists of a spaced fracture (up to 2cm) with, at one extreme, only slight crenulation of the microlithon to, at the other extreme, a tightly folded microlithon between the fractures. Alternatively, S_3 may be the axial surface to small, open to tight, crumple folds of wavelength 1mm to 2cm, which have no associated fracture. The most intense and most consistently developed S_3 occurs in phyllites. In the latter rocks differentiated crenulation cleavage (plate 4) is often developed and earlier foliations are difficult to recognize, due to their transposition into the S_3 direction.

LATER STRUCTURES

The S_3 cleavage has locally been folded by close F_4 minor folds with an associated weak crenulation cleavage of average orientation 296/68°N. F_4 folds are best developed in micaceous quartzite and phyllite on the SW limb of the Mc. Partlan Synform, but they occur sporadically in these rock types throughout the area. No F_4 folds have been observed in quartzites.

Later folds include F_5 kink bands, chevron kinks and conjugate kinks, and larger scale, open, concentric folds in more thickly layered rocks. The F_5 kinks have an average axial surface orientation of 250/70° SSE. A broad, open refold of the Mc. Partlan Synform has an axial surface with this orientation and is probably a major F_5 fold. Another, later, set of kink folds (F_6) has an average axial surface orientation of 008/60° E.

METAMORPHISM

The quartzite-phyllite assemblage of the Mc. Partlan Pass - Sentinels area is mineralogically relatively simple. In phyllites muscovite, a pale-green iron-rich variety, varies from 40% to 90% of the total rock. Chlorite is nearly always present, but is usually only a minor component ($\leq$ 10%). Some pyrite in minor to accessory amounts may alwo be present. The micaceous quartzites are composed of quartz (60% - 90%, muscovite (5% - 35%) and, in some cases, chlorite ($\leq$ 5%). Plagioclase, of composition An_4 to An_{12}, is sometimes present as a minor component ($\leq$ 5%). Accessory minerals include tourmaline, zircon, pyrite, microcline, apatite and rutile.

Chemical analyses of selected examples are shown on table 1. The analysed samples have been plotted on an A'KF facies diagram (fig. 3), which indicates the assemblage belongs to the lower greenschist facies of metamorphism (Turner and Verhoogen 1960, p.534). The possible range of conditions of metamorphism for this assemblage is: temperature 200°C to 350°C and pressure 10^2 MPa (1 Kb) to 9 x 10^2 MPa (9 Kb). The intense foliation, associated with early deformation in many rocks in this area, indicates that metamorphism took place under conditions of high stress. Although mineralogically simple, the pelitic rocks are texturally very complex. A study of crystallization with respect to various foliations (S_1, S_2 and S_3) indicates a relatively complex history of mineral paragenesis, This is summarized in figure 4. Most of the new mineral development occurred during D_1 and, to a lesser extent, during D_2 There was also a prominent static phase between D_1 and D_2, during which porphyroblasts of chlorite and albite grew over S_1 in rocks with suitable composition. In general only minor recrystallization accompanied the D_3 event and very little occurred after D_3.

PLATE 4.-Differentiated S_3 crenulation cleavage in phyllite, with darker bands of mica growing parallel to the S_3 surface.

There is no definite evidence from the present mineral assemblage as to when the metamorphic maximum was reached, if indeed there was such a climax. Some plagioclases have an oligoclase (An_{12}) composition which may indicate that the temperature did at some stage reach 350°C or higher. Some samples have idioblastic to subidioblastic chlorite flakes, which are post-S_1 but pre-S_2, and which appear to pseudomorph biotite flakes. It is possible that they formed from biotite during retrograde metamorphism, in which case the metamorphic maximum could be put at between D_1 and D_2, when biotite grade was reached. However this idea is speculative since no remnant biotites have been found.

The concept that retrograde metamorphism has occurred may be supported by the fact that the dominant muscovite in all specimens subject to X.R.D. analysis to 3T rather than 2M. Certainly, the multifoliated nature of many of these rocks would have made them particularly susceptible to retrograde effects, due to the ease of penetration, on all scales, of aqueous fluids.

TABLE 1

CHEMICAL ANALYSES OF PRECAMBRIAN METAMORPHIC ROCKS FROM THE MC PARTLAN PASS - SENTINELS AREA

	1	2	3	4	5	6	7
SiO_2	60.16	66.24	69.51	73.89	79.60	84.07	87.66
Al_2O_3	20.69	16.23	15.25	11.81	8.30	8.24	4.84
Fe_2O_3	0.00	1.66	1.24	0.71	0.18	0.00	0.24
FeO	2.60	1.88	2.62	1.02	2.25	0.51	2.10
MnO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TiO_2	0.85	0.65	0.70	0.29	0.27	0.28	0.49
P_2O_5	0.07	0.03	0.00	0.05	0.01	0.02	0.01
CaO	0.01	0.01	0.01	0.03	0.01	0.00	0.01
MgO	4.85	1.47	1.42	4.22	5.20	1.14	1.40
Na_2O	0.52	0.25	0.40	0.30	0.11	0.82	0.25
K_2O	5.32	3.91	3.45	3.58	1.17	3.72	1.27
Ignition Loss	4.19	6.78	4.70	2.83	2.69	1.74	1.50
TOTAL	99.26	99.11	99.30	98.73	99.79	100.54	99.77

Chemical analyses of selected phyllites and micaceous quartzites from the Mc. Partlan Pass - Sentinels area. The numbers 1 to 7 refer respectively to specimens 40955, 40970, 40988, 40960, 40976, 40959, 40999, which are kept at the Geology Department, University of Tasmania.

DISCUSSION AND CONCLUSIONS

Inhomogeneous deformation is evident during D_1 since micaceous rocks have a penetrative S_1 foliation developed, but the thicker, more competent, quartzite sequences have no foliation, or only a weak foliation. The inhomogeneity of deformation may be due to local variations in the overall D_1 stress-field, but there seems to be no doubt that lithological differences have played a major role. F_1 axial surfaces were rotated into near alignment with those of F_2 due to the near isoclinal nature of the latter folds. F_2 folds are almost coplanar with the earlier folds.

The major period of metamorphism started with D_1 and continued until the end of D_2. Metamorphism was triggered by the onset of the first deformation event, during which micas were formed from pre-existing sedimentary minerals. Such reactions would have involved the release of volatiles, which would in turn affect the style of deformation by markedly increasing the creep rate (Holland and Lambert 1969). Following

the D_2 event there was probably a considerable time gap before the onset of the third deformation event, which produced the dominant folds in the area, but which was accompanied by only minor crystallization.

Cambrian quartzose conglomerates, sandstones and siltstones (Corbett 1970), to the immediate east of the Precambrian metamorphic rocks discussed herein, have two distinct sets of folds developed, which can be correlated, on the basis of orientation, with F_5 and F_6. This indicates a Palaeozoic age for these events. The conglomerate beds, within the Cambrian sequence contain pebbles and cobbles of micaceous quartzite with S_3 crenulation cleavage and L_3 crumple lineations developed. These structures are not present in the bulk of the rock and so D_3, as well as the earlier D_1 and D_2 events, probably a Precambrian event. D_4 may be a late Precambrian, or early Palaeozoic event.

Corbett (1970) regarded the metaconglomerate unit as either Cambrian or Precambrian. This unit has been found to contain all the early structures, including S_1, S_2 and S_3, of the metamorphosed Precambrian rocks to the south and west. It is thus regarded as being Precambrian in age.

Events D_1 and D_4 can probably be correlated with D_1 to D_4 in the Frankland and Wilmot Ranges (Boulter 1974). Correlation of this sequence with published structural sequences from elsewhere in the Older Precambrian of Tasmania, can be found in Table 1 of Boulter (1974)

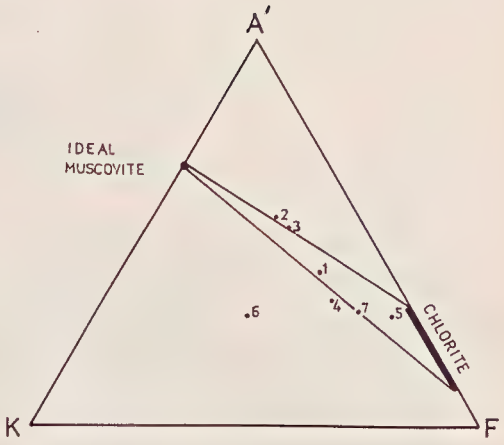

FIG. 3.- An A'KF facies diagram for selected phyllites and micaceous quartzites from the Mc. Partlan-Pass-Sentinels area.

$A' = [Al_2O_3] + [Fe_2O_3] - ([Na_2O] + [K_2O] + [CaO])$

$K = [K_2O]$

$F = [FeO] + [MgO] + [MnO]$

No specific corrections have been made. Muscovite and chlorite have not been analysed separately and their position on the plot has been taken from Turner and Verhoogen (1960, p.537) and Winkler (1967, p.61).
The numbers refer to the same specimens as in Table 1.

ACKNOWLEDGEMENTS

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DEFORMATION PHASE	D_1			D_2		D_3	
S SURFACE	S_1			S_2		S_3	
MINERAL ↓	PRE	SYN	POST	SYN	POST	SYN	POST
QUARTZ							
MUSCOVITE							
CHLORITE							
ALBITE							

FIG. 4.-The chronological relationship between metamorphic crystallization and S-surfaces in pelitic rocks from the Mc. Partlan Pass-Sentinels area.

manuscript and Mr. R. Williams who assisted in the preparation of the illustrations.

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A SUMMARY OF THE OLDEST AGES FOR THE WORLD'S ISLANDS

by Oakley Shields
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ABSTRACT

The oldest ages of rocks on the world's islands are summarized (Oligocene or older), based on published literature. All the oceans and perhaps all the seas contain a few continental islands, indicative of debris left from continental rifting prior to ocean basin formation by seafloor spreading. The Musicians Seamounts and the Hawaiian Ridge (both Cretaceous), and the Tuamotu Islands (Eocene) are the same age as the surrounding seafloor and probably formed at the crest of the East Pacific Rise. Future drilling and dredging operations are expected to modify and add to this list, as recent volcanism may well have obscured the much older basement rocks on many islands. Thus, the faunas of the Galapagos, Mauritius, Rodriguez, and Tristan da Cunha suggest they are continental islands, while their known surface geology yields dates of only 8 m.y. or less.

INTRODUCTION

The following is a summary of the oldest ages (i.e. Oligocene or older) of rocks on the world's islands (including some seamounts, guyots, and sunken plateaus), compiled from the literature. Especially interesting from tectonic and biogeographic considerations are islands with continental rock-types. "'Continental rocks'include plutonic rocks such as granite and diorite and metamorphic rocks such as schist and slate. As a general rule such rocks are not found except on continents or on islands obviously once connected with continents. The deep-seated plutonic rocks are exposed only after prolonged erosion and most islands have not suffered sufficient erosion even if it be assumed that they have a plutonic core. The metamorphic rocks demand powerful earth movements and these cannot be developed on tiny land masses. Hence, the occurrence of either plutonic or metamorphic rocks on an island suggests that it once was a part of a much larger land mass. The 'island rocks' consist largely of volcanic rocks and limestones and sediments derived from these" (Wentworth & Ladd 1931, p.6). According to Daly (1916a), Pacific islands having rock types characteristic of large areas in the continents include granite, gneiss, schist, serpentine, and deformed sediments (However, more recent work suggests granitic metamorphism requires diapiric transport up from significant depths and is not excluded from islands (Carey *pers. comm.*); serpentine is known to occur along some transform faults, and mid-ocean ridges (Chernysheva 1971), and it has been reported from the Puerto Rico Trench by Perfit, Heezen, and Rawson 1974.) Schists can occur in shear-zones. A continental flora or fauna means that that island resembles a continent in aspect rather than an oceanic island - i.e., the biota is not markedly impoverished, or forms are present such as land turtles, amphibians, flightless birds or the like which suggest past contacts with a continent. The distinction between oceanic and continental islands was first made by Charles Darwin; oceanic islands are volcanic or coral and lack native mammals and amphibians (Wallace 1887).

A Summary of The Oldest Ages for the World's Islands

OLDEST AGES FOR ISLANDS

Island	Latitude & Longitude	Age	Source
ATLANTIC OCEAN			
Greenland	74.00N,40.00W	continental; Archaean	Menard & Ladd 1963; Pidgeon & Hopgood 1975
Franz Joseph Land	81.00N,55.00E	Jurassic	Arkell 1956
The Faeroes Islands	61.53N,5.58W	Eocene (?)	Wilson 1963
Spitzbergen & King Charles Islands	77.00N,20.00E	Jurassic	Arkell 1956
Iceland	65.12N,19.45W	continental, or Eocene	Wilson 1963 Menard & Ladd 1963
Andoe Island (nr. Norway)	58.06N,7.59E or 65.58N,12.17F	Jurassic	Arkell 1956
Rockall Bank	57.37N,13.40W	Precambrian; continental	Roberts, Ardus, & Dearnley 1973; Roberts 1975
Rockall Islet	57.40N,13.30W	Eocene	Roberts, Ardus, & Dearnley 1973
Holy Island, N.Wales	53.45N,4.45W	Silurian/ Devonian	Harland, Smith & Wilcock 1964
Isle of Wight	50.44N,1.17W	Lower Cretaceous	Harland, Smith & Wilcock 1964
British Isles	55.34N,7.45W	continental	Carlquist 1965
Vigo Seamount off Portugal	41.14N,10.42W	Jurassic	Black *et al.* 1964
Galicia Bank off Portugal	42.40N,11.55W	Upper Cretaceous	Black *et al.* 1964
Cape Breton Island (Nova Scotia)	45.48N,59.53W	Precambrian/ Cambrian	Cromier 1973
Azores Swell		continental rocks	Axelrod 1960
Azores	37.44N,29.25W	continental	Alexrod 1960; Carlquist 1965
Madeira	32.41N,16.15W	Cretaceous (?)	Wilson 1963
Canary Islands	28.30N,15.10W	continental	Axelrod 1960; Carlquist 1965
Fuerteventura	28.25N,14.00W	continental crust; or Mesozoic	Dietz & Sproll 1970; Rothe 1974
Lanzarote	29.00N,13.38W	continental fauna; or Mesozoic	Rothe 1974

Island	Latitude & Longitude	Age	Source
Tenerife	28.15N,16.35W	continental fauna	Rothe 1974
Cape Verde Islands	16.00N,24.00W	continental	Carlquist 1965
Maio I.	15.14N,23.10W	Upper Jurassic	Smith 1971; Mitchell-Thome 1974
Sao Nicolao Islands	16.35N,24.15W	Upper Jurassic (?)	Mitchell-Thome 1974
Conception Bank	23.55S,14.30E	continental crust	Dietz & Sproll 1970
Fernando Poo	3.22N, 7.37E	Cretaceous (?)	Mitchell-Thome 1970
Principe	1.42N, 5.38E	end of Cretaceous (?)	Mitchell-Thome 1970
Sao Tome	0.41N, 6.01E	Lower Cretaceous (?)	Mitchell-Thome 1970
Annobon	2.00S, 3.30E	Cretaceous (?)	Mitchell-Thome 1970
Bermuda	32.18N,64.45W	Eocene, pre-Eocene, or Triassic (?)	Reed 1949; Wilson 1963; Engelen 1964, Reynolds 1973
Bahamian Platform		Jurassic; or Palaeozoic (?)	Lynts 1970
Bahamas	26.15N,76.00W	Early Cretaceous	Wilson 1963
Demerara Plateau (off South America)	9.26N,54.06W	Late Jurassic/ Early Cretaceous	Fox, Heezen, & Johnson 1970
St. Peter & St.Paul Rocks	0.56N,29.22W	4550+ m.y.	Wright 1965
Fernando de Noronha	3.50S,33.15W	Upper Cretaceous	Mitchell-Thome 1970
Ascension	8.00S,13.00W	continental rocks (?)	Alexrod 1960; Carlquist 1965; Mitchell-Thome 1970
St. Helena	16.01S, 5.16W	Eocene	Mitchell-Thome 1970
Walvis Ridge		continental rocks	Axelrod 1960
Trinidade	21.00S,32.00W	continental rocks	Axelrod 1960
Martin Vaz	20.30S,28.52W	Upper Cretaceous	Mitchell-Thome 1970
Tristan da Cunha	35.30S,12.15W	continental	Axelrod 1960; Carlquist 1965
Meteor Bank		continental rocks	Axelrod 1960

A Summary of The Oldest Ages for the World's Islands

Island	Latitude & Longitude	Age	Source
Falkland Islands	50.45S,61.00W	Precambrian	Mitchell-Thome 1970
islands of the North & South Scotia Ridges		continental rocks (?Palaeozoic or older)	Dalziel 1972
South Georgia	54.00S,37.00W	continental; or Jurassic/ Cretaceous	Axelrod 1960; Carlquist 1965; Elliot 1975
South Orkneys	60.38S,45.30W	continental; Precambrian	Alexrod 1960; Carlquist 1965; Elliot 1975
Signy I.	60.43S,45.36W	176-199 m.y.	Alexrod 1960; Carlquist 1965
Moe I.	60.45S,45.41W	176-199 m.y.	Axelrod 1960; Carlquist 1965
South Shetlands	62.00S,58.00W	continental; or Late Palaeozoic	Axelrod 1960; Carlquist 1965; Elliott 1975
Alexander Island	71.00S,71.00W	Late Palaeozoic	Elliot 1975
Northern Antarctic Peninsula		Middle Palaeozoic	Elliot 1975
MEDITERRANEAN SEA			
Gilbraltar	36.08N, 5.22W	Jurassic (?)	Reed 1949
Minorca	40.00N, 4.00E	Palaeozoic	Arkell 1956
Mallorca (Majorca)	39.30N, 3.00E	Palaeozoic	Arkell 1956
Corsica	42.10N, 8.55E	Upper Palaeozoic	Arkell 1956; Klemme 1958
Sardinia	40.08N,9.05E	Lower Palaeozoic	Arkell 1956; Klemme 1958
Island of Elba	42.42N,10.25E	Upper Jurassic	Grunau 1965
Sicily	37.38N,13.30E	Upper Palaeozoic	Klemme 1958
Maltese Islands	36.00N,14.15E	Oligocene	Reed 1949
Crete	35.15N,24.30E	Upper Palaeozoic	Klemme 1958
Cyprus	34.56N,31.28E	Upper Palaeozoic	Reed 1949; Klemme 1958
Ionian Isles	39.10N,20.05E	Jurassic	Arkell 1956

Island	Latitude & Longitude	Age	Source
INDIAN OCEAN			
Bahrain Islands (Persian Gulf)	26.15N,51.17E	Cretaceous	Reed 1949
Socotra	13.00N,52.30E	continental; Archaean	Forbes 1903; Van Balgooy 1969
Abd-El-Kuri	12.21N,51.00E	Archaean	Forbes 1903
Ceylon	8.45N,82.30E	Precambrian	Reed 1949; Crawford & Oliver 1969; Katz 1971
Laccadive, Maldive, & Chagos Islands		continental crust (?)	Axelrod 1960
Seychelles	5.20S,55.10E	Precambrian	Wilson 1963
Mahe	4.41S,55.30E	645 ± 55 m.y.	Baker & Miller 1963
Silhouette Is.	4.29S,55.12E	62 ± 12 m.y.	Baker & Miller 1963
Praslin	4.18S, 55.45E	647 ± 55 m.y.	Baker & Miller 1963
Northern end of the Mascarene Ridge & Cargados Carajos Shoals		continental crust	Matthews & Davies 1966
Mauritius	20.18S,57.36E	continental rocks; or Cretaceo-Tertiary	de Haga Haig 1895; Axelrod 1960; Carlquist 1965; Simpson 1950
Providence	9.14S,51.02E	Eocene/Oligocene	Reed 1949; Wilson 1963
Comores Islands	11.46S,44.12E	continental rocks	Axelrod 1960; Carlquist 1965; Flower & Strong 1969 (but see Wright & McCurry 1970)
Madagascar	21.30S,46.00E	Precambrian	Wilson 1963
St. Paul	38.43S,77.31E	continental rocks	Axelrod 1960; Carlquist 1965
Kerguelen	49.50S,69.30E	continental rocks; or Upper Cretaceous-Palaeocene	Axelrod 1960; Carlquist 1965; Nougier 1972
Heard Island	53.10S,74.35E	continental rocks; or Lower Tertiary	Axelrod 1960; Stephenson 1963
Crozet (Possession) Island	46.20S,51.30E	continental rocks	Axelrod 1960; Carlquist 1965

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Island	Latitude & Longitude	Age	Source
Andamans-Nicobars	11.38N,92.17E	continental crust	Peter, Weeks & Burns 1966
Andaman Island	11.41N,92.46E	Eocene (?)	Glaessner 1943
Christmas	10.35S,105.40E	continental; or Eocene	Marshall 1927; Wilson 1963; Van Balgooy 1969
Wallaby Plateau		continental crust	Geomagnetism Correspondent 1973
Exmouth Plateau		continental crust	Geomagnetism Correspondent 1973
Naturaliste Plateau		continental crust	Petkovic 1975
Broken Ridge		continental crust	Petkovic 1975
INDONESIA-PHILIPPINES			
Langkawi Island	6.22N,99.50E	Palaeozoic	Katili 1971
Riouw Archipelago	0.49N,103.45E	Triassic	Umbgrove 1938
Sumatra	2.06N,99.40E	continental rocks	Woolnough 1903; Umbgrove 1949; Carlquist 1965
Java	8.35S,111.11E	continental crust (?)	Woolnough 1903; Cloud 1953
Bali	8.00S,115.22E	continental	Carlquist 1965
Timor	10.08S,125.00E	Permian	Umbgrove 1949
Letti Island	8.12S,127.41E	Permian	Umbgrove 1949
Billiton Island	2.50S,107.56E	Triassic/ Jurassic	Harland, Smith & Wilcock 1964
Barbar, Moa, Sawu, Rotti		Permian	Umbgrove 1949
Jamdena	7.23S,130.30E	Jurassic	Umbgrove 1938
Bathurst Island	11.35S,131.41E	Cretaceous	Wright 1963
Tambelan & Bunguran Islands	0.38N,107.38E	Late Cretaceous	Haile & Bignell 1971
Tanimbar, Boeton, Boeroe, Ambon, Banka, Billiton, Rendjoewa, Savoe, Misool, the Moluccas		Triassic	1938

Island	Latitude & Longitude	Age	Source
Borneo	0.25N,112.39E	continental crust (?)	Woolnough 1903; Reed 1949; Cloud 1953
Celebes	2.15S,120.30E	Triassic	Umbgrove 1949
Soela Islands	2.20S,125.20E	end of Palaeozoic (?)	Umbgrove 1938
Kei Islands	5.35S,132.45E	Eocene	Glaessner 1943
Ceram	3.00S,129.00E	Triassic	Grunau 1965
Buru	3.30S,126.30E	Jurassic	Arkell 1956
Obi	1.25S,128.15E	Jurassic	Umbgrove 1949
Halmahera	0.45N,128.45E	Cretaceous	Umbgrove 1938
Philippines	14.25N,125.00E	continental crust (?), in part	Cloud 1953; Carlquist 1965
Mindanao	7.30N,125.10E	continental rocks	Irving 1952
Negros	9.50N,121.45E	continental rocks	Irving 1952
Cebu	10.22N,123.49E	Cretaceous (?)	Irving 1949
Palawan	9.50N,117.38E	continental rocks	Irving 1952
Mindoro	13.04N,121.06E	Jurassic (?)	Irving 1949; Arkell 1956
Luzon	17.10N,119.45E	continental rocks	Irving 1952
BERING SEA			
St. Matthew Island	60.25N,172.10W	Upper Cretaceous	Patton, Lanphere, Miller, & Scott 1974
PACIFIC OCEAN			
Eastern edge of Pacific			
I. Alaskan Peninsula:			
Aleutian Islands	52.40N,177.30E	latest Cretaceous, early Tertiary, or Early Oligocene	Burk 1965; Scholl, Marlow, & Buffington 1975
guyot in Aleutian Trench		early Tertiary or older	Wilson 1963
Adak Island	51.40N,176.28W	Permian	Packham & Falvey 1971
outer Shumagin Islands	55.22N,159.20W	Upper Cretaceous	Burk 1965

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Island	Latitude & Longitude	Age	Source
Sanak Island	54.26N,162.40W	Upper Cretaceous	Burk 1965
Semidi Is. & Chirikof Is.	55.50N,155.35W	Late Mesozoic	Burk 1965
Kodiak Islands	57.24N,153.32W	Palaeozoic	Burk 1965
II. San Juan Is., Washington			
San Juan Islands	48.30,123.05W	Devonian	McLellan 1927
III Channel Islands			
San Miguel I.	34.03N,120.23W	Late Cretaceous	Weaver 1969
Santa Rosa	34.02N,120.15W	Eocene	Weaver 1969
Santa Cruz I.	34.05N,119.55W	Late Jurassic	Weaver 1969
San Nicolas	33.14N,119.10W	Eocene	Weaver 1969
Santa Catalina I.	33.29N,118.37W	continental rock	Van Balgooy 1969
IV. Gulf of California			
San Lorenzo I., Angel de la Guarda I., Tiburon I., San Pedro Nolasco I., Consag Rock, Santa Catalina I., Santa Cruz I., San Diego I., San Jose I., & Cerralvo I.		pre-Tertiary basement	Anderson 1950
V. off the South American coast			
Galapagos Islands	0.10S,87.45W	continental biota	Baur 1897
San Felix & San Ambrosio	26.40S,80.00W	continental flora	Kuschel 1963
Juan Fernandez	33.30S,79.00W	continental biota	Kuschel 1963
Northwest Pacific margin			
Kamchatka-Kuril-Hokkaido Arc		continental	Menard & Ladd, 1963
Sakhalin	51.52N,144.15E	continental	Carlquist 1965
Japan	36.30N,133.30E	continental	Carlquist 1965
Ryukyu Islands	26.00N,119.00E	continental (?)	Cloud 1953

Island	Latitude & Longitude	Age	Source
Taiwan	23.30N,122.20E	continental	Cloud 1953; Carlquist 1965
West Pacific			
Bonin Islands	27.00N,142.10E	Middle Eocene	Cloud 1953; Karing 1971; Karig *et al.*,1973; Karig & Moore 1975
Southern Marianas	17.20N,145.00E	Eocene	Cloud 1953
Saipan	15.12N,145.43E	Middle Eocene	Hanzawa 1957; Cole 1963; Tracey *et al.* 1964; Karig *et al.*1973
Tinian	14.58N,145.38E	Eocene	Hanzawa 1957
Rota	14.10N,145.15E	Eocene	Hanzawa 1957
Guam	14.00N,143.20E	Middle Eocene	Cole 1963; Tracey *et. al.* 1964; Karig *et. al.*1973
Magellan Rise		Upper Jurassic	Larson & Chase 1972
Yap	11.00N,138.00E	continental rocks (?)	Daly 1916; Gregory 1928, 1930
Palau Islands	7.15N,134.30E	Middle Eocene	Cloud 1953; Hanzawa 1957; Karig *et al.* 1973
Babelthuap	7.30N,134.36E	continental rocks or Late Eocene	Daly 1916; Mason & Corwin 1953; Hanzawa 1957
Malakal	7.20N,134.28E	continental rocks	Marshall 1911
West Carolines	9.30N,143.00E	continental flora	Van Balgooy 1969
Truk	7.28N,151.51E	continental	Daly 1916; Gregory 1928 (but see Bridge 1948)
Maprong		continental	Gregory 1928
Ponape	6.55N,158.15E	Eocene/Oligocene	Van Balgooy 1969
Map	9.35N,138.11E	continental rocks	Daly 1916
Southwest Pacific			
Ontong Java Plateau (= Solomon Rise)		Late Cretaceous	Hammond *et al.* 1975
New Guinea	5.45S,140.00E	continental rocks	Reed 1949; Umbgrove 1949
Bismarck Archipelago	3.15S,150.45E		
New Britain	6.45S,149.38E	Cretaceous (?)	Reed 1949
New Ireland	3.15S,152.30E	Lower Oligocene	Reed, 1949

A Summary of The Oldest Ages for the World's Islands

Island	Latitude & Longitude	Age	Source
Lou	2.25S,147.23E	continental rocks	Daly 1916
Macada		continental rocks	Daly 1916
New Hanover	2.37S,150.15E	continental rocks	Daly 1916
New Mechlenburg		continental rocks	Daly 1916
Solomon Islands	7.00S,148.00E	continental	Baur 1897; Griffiths 1971
Guadalcanal	9.48S,158.43E	continental rocks	Grover 1955
San Cristobal	10.47S,162.17E	continental rocks	Reed 1949; Grover 1955
St. George	8.30S,159.36E	continental rocks	Grover 1955
Vulavu	8.31S,159.48E	continental rocks	Woolnough 1903
Faro (Fauro)	6.55S,156.05E	continental rocks	Daly 1916
Shortland Islands	7.05S,155.45E	continental rocks	Daly 1916
Savo I.	9.10S,159.50E	Lower Cretaceous	Coleman 1970
Russell I.	9.16S,158.30E	Lower Cretaceous	Coleman 1970
Choiseul	7.30S,157.30E	51.5 m.y.	Richards *et al.* 1966
Malaita	8.38S,161.15E	Upper Cretaceous	Coleman 1966b, 1970
Malaita group		Oligocene or older (?)	Univ. Sydney 1956
Central Province - (Bougainville, Choiseul, Santa Ysabel, Florida Group, Guadalcanal, San Cristoval)		Mesozoic (probably Cretaceous) basal complex	Coleman 1966a
San Jorge	8.27S,159.35E	pre-Tertiary (?)	Univ. Sydney 1956
Florida I	9.05S,160.15E	continental rocks	Marshall 1911
Santa Ysabel	8.00S,159.00E	pre-Tertiary (?)	Univ. Sydney 1956; Stanton 1961
Louisiade Ridge		continental crust	Griffiths 1971
Rennell Ridge		continental crust	Griffiths 1971
Queensland Plateau		continental crust	Griffiths 1971

Oakley Shields

Island	Latitude & Longitude	Age	Source
New Hebrides	16.02S,169.15E	continental mass	Reed 1949
Malicolo	16.15S,167.30E	continental rocks	Woolnough 1903
Spiritu Santo	15.15S,166.50E	continental rocks	Woolnough 1903
Aneityum	20.15S,169.49E	continental rocks	Woolnough 1903
Malekula	16.44S,167.45E	continental rocks (?)	Daly 1916
Maewo	15.17S,168.16E	Upper Eocene	Coleman 1969, 1970
New Caledonia	21.30S,165.30E	Precambrian; continental rocks & flora; or Permian flora	Aronson & Tilton 1971; Marshall 1911; Avias 1953; Carlquist 1965; Van Balgooy 1969; Waterhouse 1971
Fiji Archipelago	18.50S,175.00E	continental rocks & flora	Woolnough 1903; Axelrod 1960; Van Balgooy 1969
Vanua Levu	16.33S,179.15E or 17.28S,177.03E	continental rocks	Marshall 1911; Daly 1916
Viti Levu	18,00S,178.00E	continental rocks; or Upper Eocene	Marshall 1911; Daly 1916; Cole 1960
Lau	18.20S,178.30W	Eocene	Cole 1963
Wallis Islands	13.16S,176.15W	Oligocene	Wilson 1963
Tonga Islands	18.50S,175.20W	continental mass & flora	Reed 1949; Van Balgooy 1969
Eua I.	21.23S,174.55W	continental rocks	Lister 1891; Daly 1916; Reed 1949
Kermadec Islands	30.30S,177.00E	continental rocks (?)	Marshall 1911; Gregory 1930; Axelrod 1960
Lord Howe Rise		continental crust; or Upper Cretaceous	Officer 1955; Griffiths 1971; Packham & Falvey 1971; McDougall & Van Der Lingen 1974
Lord Howe Island	31.44S,157.56E	continental rocks (?) & flora	Marshall 1911; Reed 1949; Standard 1963; Van Balgooy 1969
Norfolk Ridge		continental crust	Griffiths 1971
Norfolk Island	29.05S,167.59E	continental rocks	Daly 1916a
New Zealand	39.14S,169.30E	Precambrian	Reed 1949; Aronson 1965; Aronson & Tilton 1971

A Summary of The Oldest Ages for the World's Islands

Island	Latitude & Longitude	Age	Source
Three Kings Islands (N. New Zealand)	34.09S,172.09E	Cretaceous	Bartrum 1948
Chatham Rise		continental crust	Griffiths 1971
Chatham Islands	44.00S,178.00W	continental rocks	Axelrod 1960; Carlquist 1965
Campbell Plateau		continental crust	Adams 1962; Griffiths 1971
Campbell Island	52.30S,169.00E	continental rocks	Axelrod 1960; Carlquist 1965
Bounty Islands	47.42S,179.05E	continental rocks; or Triassic/ Jurassic	Axelrod 1960; Wasserburg *et al.* 1963; Carlquist 1965
The Snares	48.00S,116.30E	continental rocks	Daly 1916
Auckland Islands	50.30S,166.30E	continental rocks	Daly 1916; Axelrod 1960
Disappointment	50.35S,166.00E	continental rocks	Daly 1916
Macquarie Island	54.36S,158.45E	continental rocks	Axelrod 1960; Carlquist 1965
Tasmania	41.28S,142.30E	Precambrian	Reed 1949
Marie Byrd Land	78.00S,140.00W	Precambrian	Elliot 1975
Northwest to Southeast Pacific			
Shatsky Rise		Lower Cretaceous	Larson & Chase 1972; Douglas & Moullade 1972
Koko Seamount	34.47N,171.50E	Eocene (46.4 m.y.)	Clague & Dalrymple 1973
Suiko Seamount		41 m.y.	Jackson, Silver, & Dalrymple 1972
Khatchaturian Seamount	28.08N,162.17W	65 ± 3 m.y.	Clague & Dalrymple 1975
Rachmaninoff Seamount	29.33N,163.22W	87 ± 5 m.y.	Clague & Dalrymple 1975
Wentworth Seamount	28.54N,177.52W	71 ± 5 m.y.	Clague & Dalrymple 1975
Necker Island	23.48S,164.25W	78 ± 2 m.y.	Clague & Dalrymple 1975
3 seamounts SW of the Hawaiian Islands		Cretaceous (85-90 m.y.)	Dymond & Windom 1968
Line Islands	0.05N,157.00W	Upper Cretaceous	Schlanger *et al.* 1974a, b

Oakley Shields

Islands	Latitude & Longitude	Age	Source
Horizon Guyot	19-20N,169.00W	Eocene	Hamilton 1956
Kapsitotwa Seamount		128 m.y.	Clague & Dalrymple 1975
Guyot 19171	23.00N, 00W	Lower Eocene	Hamilton 1956
Hess Guyot	17.50N,174.15W	Middle Cretaceous	Hamilton 1956
Cape Johnson Guyot	17.08N,177.15W	Middle Cretaceous	Hamilton 1956
Shepard, Jacqueline, & Menard seamounts or guyots		88-100 m.y.	Clague & Dalrymple 1975
guyots in the northern Marshall area		Late Mesozoic	Emery, Tracey, & Ladd 1954
Marshall Islands	10.00N,165.00E	Upper Eocene	Coleman 1969
Eniwetok	11.21N,162.20E	Late Mesozoic (?) or Late Eocene	Cloud 1953; Hamilton 1956; Cole 1963; Tracey *et al.* 1964
Bikini	11.35N,165.20E	Eocene; or Oligocene (?)	Emery, Tracey, & Ladd 1954; Hanzawa 1957; Cole 1963
Sylvania Guyot		Lower Eocene	Wilson 1963
Cook Islands	20.00S,158.00W		
Mauke	20.09S,157.23W	Cretaceous; or Early Tertiary	Wood & Hay 1970
Mitiaro	19.49S,157.43W	Cretaceous; or Early Tertiary	Wood & Hay 1970
Atiu	20.00S,158.07W	Cretaceous; or Early Tertiary	Wilson 1963; Wood & Hay 1970
Aitutaki	18.52S,159.46W	Cretaceous; or Early Tertiary	Wilson 1963; Wood & Hay 1970
Mangaia	21.56S,157.56W	end of Cretaceous; or Eocene; or Oligocene	Marshall 1927; Gregory 1930; Wood 1967; Wood & Hay 1970
Rarotonga	20.40S,163.00 W	Cretaceous	Marshall 1930
Northern Group atolls		Early Tertiary	Wood & Hay 1970
Manihiki Plateau		Cretaceous	Schlanger *et al.* 1974b

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Island	Latitude & Longitude	Age	Source
Tubuai Islands	23.23S,149.27W		
Rimatara	22.40S,152.45W	continental rocks	Williams 1933; Wood & Hay 1970
Tubuai	23.23S,149.27W	25 ± 10 m.y.	Krummenacher & Noetzlin 1967
Rapa	27.36S,144.20W	continental rocks & flora	Williams 1933; Wilson 1963 Van Balgooy 1969; Woods & Hay 1970
Society Islands	17.00S,150.00W		
Maupiti	16.27S,152.15W	continental rocks (?)	Gregory 1930
Bora-Bora	16.30S,151.45W	continental rocks (?)	Marshall 1911; Daly 1916
Moorea	17.32S,149.50W	continental rocks (?)	Wilson 1963
Tahiti	17.30S,149.30W	continental rocks; 833 m.y.; or 156 ± 15 m.y.	Wilson 1963; Krummenacher & Noetzlin 1967; Krummenacher *et al.* 1972
Tahiti-Iti	17.47S,149.14W	continental rocks	Wilson 1963
Tuamotu Ridge		pre-early Eocene	Schlanger *et al.* 1974a
Tuamotu Islands	19.00S,142.00W		
Makatea	15.50S,148.15W	Eocene	Wilson 1963
guyot amid the atolls of the Tuamotu Archipelago		Eocene	Menard & Ladd 1963
guyots among the Tuamotu Islands		40 - 45 m.y.	Vogt & Ostenso 1967
Marquesas Islands	8.50S,141.00W	continental rocks (?)	Gregory 1930
Easter Island	26.50S,109.00W	continental rocks (?)	Marshall 1911; Daly 1916; Stearns 1945, p.617; King 1962 p.606, 609
Sala-y-Gomez	26.28S,105.28W	continental rocks	King 1962, p.606

Island	Latitude & Longitude	Age	Source
CARIBBEAN— GULF OF MEXICO			
Cuba	22.00N,79.00W	Palaeozoic (?); or Middle Jurassic	Schuchert 1935; Weyl 1966
Isla de Pinos	21.40N,82.50W	Late Palaeozoic or Mesozoic	Weyl 1966; Baie 1970
Cayman Ridge & Nicaragua Rise		continental crust	Khudoley & Meyerhoff 1971
Jamaica	18.21N,77.31W	Palaeozoic (?); or pre-Cretaceous; or Upper Cretaceous	Schuchert 1935; Reed 1949; Harland, Smith & Wilcock 1964; Weyl 1966
Hispaniola	17.30N,73.15W	Palaeozoic or Mesozoic	Weyl 1966
Haiti		Palaeozoic (?); or Lower Cretaceous	Schuchert 1935; Butterlin 1956
Santo Domingo		pre-Jurassic (?)	Khudoley & Meyerhoff 1971
Puerto Rico	17.45N,66.55W	pre-Jurassic (?); or Lower Cretaceous	Butterlin 1956; Khudoley & Meyerhoff 1971
Virgin Islands	18.20N,64.45W	Cretaceous	Hess 1937
Culebra	18.19N,65.32W	early Upper Cretaceous	Donnelly 1971
St. Thomas	18.22N,64.57W	pre-Upper Cretaceous	Christman 1953; Donnelly 1971
St. John	18.16N,64.48W	pre-Upper Cretaceous	Donnelly 1971
St. Croix	17.40N,64.43W	Late Cretaceous	Khudoley & Meyerhoff 1971
Ginger Island, Cooper's Island, Salt Island (small islets in Virgin Is.)		pre-Cretaceous	Reed 1949
Anguilla	18.15N,62.54W	Middle Eocene	Reed 1949
St. Martin	18.06N,62.54W	Cretaceous (?)	Maxwell 1948

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Island	Latitude & Longitude	Age	Source
St. Barthelemy	17.55N,62.32W	Middle Eocene (?)	Christman 1953; Martin-Kaye 1969
The "Limestone Caribbees" (Sombrero, Anguilla, St.Martin, Tintamarre, St. Barthelemy, Barbuda, Antigua, Grande Terre of Guadeloupe, Desirade, & Marie Galante)		Eocene or older	Maxwell 1948; Martin-Kaye 1969
Saba, St. Eustatius, St. Kitts, Gaudeloupe, Dominica, Martinique, St. Lucia, St. Vincent, & Grenada		ejected fragments of continental basement	Westermann & Kiel 1961, p.168
"Volcanic Caribbees" (from Saba in the north to Grenada in the south)		Eocene	Weyl 1966
Windward Islands (from Dominica to Grenada)		basement of trappean rocks beneath early Tertiary formations	Spencer 1902
Antigua	17.07N,61.32W	pre-Cretaceous (?)	Reed 1949
Montserrat	16.48N,62.00W	Late Cretaceous (?) or Early Eocene	Reed 1949
Desirade	16.21N,60.51W	Jurassic or older	Meyerhoff 1974
Dominica	15.24N,61.05W	pre-Tertiary (?); or Eocene	Earle 1928; Reed 1949
Martinique	14.30N,60.37W	Cretaceous	Hill 1905; Hess 1937
Bequia	13.00N,61.08W	Eocene (?)	Martin-Kaye 1969
Mustique	12.53N,61.03W	Lower Eocene (?)	Martin-Kaye 1969
Canouan	12.44N,61.10W	Upper Eocene (?)	Martin-Kaye 1969
Mayreau	12.39N,61.23W	Lower Eocene (?)	Martin-Kaye 1969
Carriacou	12.28N,61.20W	Upper Eocene	Martin-Kaye 1969
Petit Martinique	12.30N,61.25W	Upper Eocene	Martin-Kaye 1969

Island	Latitude & Longitude	Age	Source
Grenada	12.02N,61.27W	Upper Eocene	Martin-Kaye 1969
Barbados	13.30N,59.48W	Early Eocene	Maxwell 1948; Christman 1953; Weyl 1966
Tobago	11.15N,60.30W	Cretaceous	Christman 1953; Butterlin 1956
Trinidad	10.30N,60.30W	Jurassic	Christman 1953; Butterlin 1956
Patos Island	10.36N,61.54W	Early Cretaceous	Kugler 1974
Margarita	11.00N,64.15W	Mesozoic; or Cretaceous (?)	Butterlin 1956; Weyl 1966
Bonaire	12.10N,68.15W	Upper Cretaceous	Maxwell 1948; Butterlin 1956
Curacao	12.12N,68.58W	Upper Cretaceous	Maxwell 1948; Butterlin 1956
Aruba	12.29N,70.00W	Upper Cretaceous	Maxwell 1948; Butterlin 1956
Gran Roque	11.50N,66.45W	Upper Cretaceous (?)	Butterlin 1956
Los Hermanos	11.45N,66.28W	Upper Cretaceous (?)	Butterlin 1956
Blanquilla	11.51N64.37W	early Eocene	Butterlin 1956
Los Testigos	11.22N.63.06W	early Eocene	Butterlin 1956

DISCUSSION

It is illogical to assume that the oldest ages determined for islands are all correct, as more recent volcanic outpourings have been obscured older, underlying plutonic and metamorphic basement rocks. Only more geologic exploration, dredging, and drilling operations will uncover the answers. Examples follow of islands where only comparatively recent ages have been determined that instead may be continental in origin. McBirney and Williams (1969) reported fossils of late Miocene age for the Galapagos Islands; Cox and Dalrymple (1966) found that K-Ar ages from whole-rock basalt samples for six of the Galapagos islands ranged from only .09 to 4.2 m.y.old. Yet Baur (1897) showed the biota to be decidedly continental. Also, giant land-tortoises occur in the Galapagos, each species restricted to a single island (Lucas 1891). Mauritius and Rodriguez are thought to be recent volcanoes of 1.6 and 8 m.y. respectively, by radiometric methods (McDougall, Upton, & Wadsworth 1965; McDougall and Chamalaun 1969). However, they possess giant land-tortoises (Lucas 1891), large flightless ground-birds, and flightless rails (Wallace 1880), evidence for a past continental contact or derivation. The last example is the Tristan da Cunha group for which Baker, Gass, Harris, and Le Maitre (1964, p. 586) reported radiometric ages (K-Ar) of only 6 ± 1.5 m.y. for Inaccessible Island and 4 m.y. for Gough Island. But an obvious archaic relict, a highly-modified flightless rail (*Atlantisia rogersi*), is restricted to Inaccessible, and an endemic land rail genus (*Porphyriornis*) occurs on Gough (Rand 1955). Thus both islands need a direct continental contact in the past to explain

this distribution. Future drilling on supposedly young volcanic islands, such as the Hawaiian Islands (McDougall 1964) and Samoan Islands (Stearns 1944) of Pliocene age, may disclose the presence of much older rocks.

Crust of continental thickness is found beneath some islands, as determined seismically and by gravity anomalies. Over much of New Zealand the crust has a typical continental thickness of 30-40 km (Thomson & Evison 1962). The Bouguer anomaly map for Viti Levu, Fiji, indicates a crust 30 km thick (Lillie and Brothers 1970). Lord Howe Rise is 29 km thick and thus is probably continental in origin (Shor, Kirk, and Menard 1971). Norfolk Ridge (22 km thick) and Campbell Plateau (average 20 km thick) are thought to probably be of continental origin (Shor, Kirk and Menard 1971; Adams 1962). Gran Canaria (15 km thick) in the Canary Islands "lies in the transition zone between oceanic and continental crust" (Bosshard and Macfarlane 1970). However, a probable high heat flow below Cyprus, the Shatsky Rise, and the Ontong Java Plateau has resulted in the up-buckling of the seafloor and a lowering of the Moho discontinuity, a process probably also taking place on Malaita in the Solomons, Macquarie Island, and elsewhere (Carey *pers. comm.*). Similarly the Agulhas Plateau, 18 km thick, is underlain by arched and faulted oceanic basement (Scrutton 1973; Emery *et al.* 1975, p.32). Thus one cannot judge continental vs. non-continental on seismic crustal thickness alone.

Clague and Dalrymple (1975) recently noted that volcanic rocks from two seamounts in the Musicians Seamounts and Necker Island, and Wentworth Seamount on the Hawaiian Ridge, showed ages at or close to their surrounding Cretaceous seafloor, indicating they formed at the crest of the East Pacific Rise. Similarly three cores from the seafloor in the Tuamotu Islands yield Eocene ages (Riedel & Funnell 1964), the same as guyots and Makatea of the Tuamotu Islands. Also, the Line Islands were 79-85 m.y. old when flow volcanism ceased on a 1270 km long segment of the chain (Schlanger 1974a, b) and may have been in contact with the South American continent at that time, since on Palmyra Atoll there is an endemic species of land-leech, an organism unlikely to be bird- or oversea-dispersed (Richardson 1975, and *in litt.*).

It is instructive to compare the oldest ages of islands with the seafloor ages of the oceans and seas containing them. In each case some of the islands predate the opening of the ocean. Thus the western Mediterranean opened in the Upper Miocene (Vogt, Higgs, & Johnson 1971), while many of the islands there are Upper Palaeozoic in age. The Scotia Sea formed in the Lower Miocene (Barker 1970), but the islands are Jurassic to Precambrian in age. The Gulf of Mexico probably formed in the Lower Cretaceous (the age of the Straits of Florida given by Wilhelm & Ewing 1972) and the Caribbean has five sites of Upper Cretaceous age from DSDP cores (Edgar *et al.* 1971), yet most of the Greater Antilles date back to the Palaeozoic. Much of the southwest Pacific formed in Lower to Upper Cretaceous times (Schlanger *et al.* 1974b; Kennett *et al.* 1973; Hayes & Ringis 1973), while continental rocks and crust are reported for many of the islands and plateaus. There is no seafloor older than the Upper Jurassic reported for the Atlantic, Indian, and Pacific Oceans (Pitman, Larson & Herron 1974; Larson 1975), yet in all three at least some of the islands and plateaus are older. The above suggests that some continental splinter fragments have been left as debris, plucked off the margins of rifting continents as ocean basins formed by seafloor spreading. In the Pacific, the distribution pattern of continental islands does not always conform to the andesite-line boundary of earlier authors.

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CHANGES IN THE ABUNDANCE OF THE VASCULAR PLANTS OF THE MOUNT WELLINGTON RANGE, TASMANIA, FOLLOWING A SEVERE FIRE

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(with two tables and one text figure)

ABSTRACT

A census of the vascular plants of the Mt. Wellington Range, Tasmania, is reported, the survey having been carried out in the two-year period between February 1973 and March 1975, i.e. six to eight years after the devasting bushfire of 7th February 1967. An earlier survey of Mt. Wellington by Martin published in 1940 provided the opportunity to examine whether the bushfire caused any extinction of plant species, or whether there were any important changes in relative species abundance.

A total of 487 native vascular species were found in the survey zone, including 450 angiosperms, representing more than one-third of the known species of native flowering plants in Tasmania. Although certain plants, e.g. some species of *Richea* and some ferns, are making a slow recovery from the effects of the fire, no important changes in the flora have been observed in comparing the present survey with the earlier one. All species observed in the survey are presented in a detailed appendix, where the abundance of each species in each of eight vegetation zones is recorded. Current practice in the botanical naming of species is observed throughout.

INTRODUCTION

The only previous published survey of the vascular plants of Mt. Wellington, Tasmania, was carried out by Martin (1940), who found a total of approximately 370 species in his survey zone, which was bordered (approximately) on the west by Thark Ridge, on the south by the North West Bay River, on the north by the New Town Rivulet, and on the east by the Derwent River (using only the area above the 800 ft. contour on the topographical map). On 7th February 1967 a disastrous fire occurred which burned and killed virtually all the vegetation of Mt. Wellington, as well as causing directly the deaths of 53 people and destroying a large number of houses and considerable property in the Hobart metropolitan area. Several years after the fire, regrowth of most species was already apparent, and the present survey is an attempt to re-examine the vascular plants of the Mt. Wellington Range, to determine which species are currently present, and to note whether any species listed by Martin (1940) are absent at the present time.

The physiography, geology, soils and climate of Mt. Wellington are dealt with by Martin (1940) and will not be discussed here. More recent accounts of these subjects for Tasmania as a whole are to be found in the Atlas of Tasmania (Davies 1965). Although Martin (1940) took an ecological approach to his survey, the present authors do not. The intention here is to present a list of plants that are currently in the survey area, to indicate the frequency of occurrence in the various zones, which with one exception, are the same as those used by Martin (1940), and to present a table which lists anomalies between the present study and the earlier study. It is hoped

that this material can then be used by ecologists to make deductions concerning the effect of fire upon plant communities.

SURVEY AREA AND VEGETATION ZONES

The survey was begun in February 1973 and continued until March 1975, a period of slightly over two years, representing a time lapse of six to eight years after the bushfire of 1967. Both authors visited the survey area together at various weekends, but it is estimated that one of us (A.V.R.) visited some portion of the survey area on more than 300 days during that period of time. The survey area itself is somewhat more extensive than that of Martin (1940), covering the entire Wellington Range (Fig.1). The authors have made use of the existence of a large network of fire roads in the range, which although not available to the public for vehicular traffic, gives foot access to portions of the range not readily accessible to Martin (1940). Figure 1 shows the fire road system, names the more important peaks of the range and shows the boundaries of the survey area. The western boundary of the survey area is the fire road extending the Jeffreys Track from Lachlan to the Crabtree Road, the southern boundary is the system of power lines paralleling the Huon Highway, the northern boundary is the Molesworth Road from Berriedale, and the eastern boundary is the Derwent River. In all cases the 240 m (ca. 800 ft.) contour is the minimum elevation. Hence, areas over 240 m in the various foothills which are outliers of Mt. Wellington, such as on Knocklofty, Chimney Pot, Tolmans, Badger and Watchorns Hills, and on Mt. Nelson, are included in the survey area. The more restricted area surveyed by Martin (1940) is shown by a dot-and-dash line on fig. 1.

Martin (1940) divided his survey area into seven vegetation sections or zones, and although other divisions could be devised (cf. Costin 1954), Martin's are retained in the present survey in order to facilitate a comparison between the two surveys. The one difference is that a zone has been added in the present work, referred to as zone 3b, which is characterized by a preponderance, amongst the eucalypts, of the gum-topped stringybark, *E. delegatensis*. Pure (or almost pure) stands of this species occur in some areas of the survey zone, and form a transition between the zone dominated by *E. obliqua* (Zone 4) and the zone dominated by *E. urnigera* (Zone 3a in the present work and Zone 3 in Martin, 1940). The characteristics of the zones used in the present study are described in the following paragraphs.

Zone 1 - Summit plateau

The summit plateau occupies a region of rather limited extent of approximately two sq. km above an elevation of ca. 1220 m at the summit of Mt. Wellington and a very much smaller area at the summit of Collins Bonnet. The region is characterized by a complete absence of trees of any kind. The zone can be divided into two distinct regions, each region having its own characteristically abundant flora, although there are areas of transition between the regions. The regions contain (i) more or less permanently wet, grassy areas, and (ii) rocky, well-drained shrubby areas. Generally a species can occur in both regions of a zone, but some species are predominant only in one region. Species common throughout zone 1 are the monocotyledons *Calorophus minor*, *Astelia alpina*, *Poa gunnii*, the shrubs *Epacris serpyllifolia*, *Monotoca empetrifolia*, the dwarf perennial *Rubus gunnianus* and the dicotyledonous herbs *Celmisia longifolia*, *Helichrysum scorpioides*. Species common only in the wet, grassy areas include the shrubs *Helichrysum hookeri*, *Olearia algida*, and the herbs *Epilobium gunnianum*, *Acaena novae-zelandiae*, *Plantago tasmanica*. Species common only in the rocky areas are the shrubs *Orites revoluta*, *Helichrysum ledifolium*, *Leptospermum rupestre* and the herbs *Haloragis montana* and *Euphrasia diemenica*.

Zone 2 - *Eucalyptus coccifera* dominant.

The snow gum *E. coccifera* forms pure stands at elevations between ca. 1100-1220 m. It is found on the rocky areas of the zone, but cannot survive in the poorly drained swampy areas such as the extensive wet grasslands which feed the headwaters of the North West Bay River. Within these grasslands, an occasional island of rocks, such as

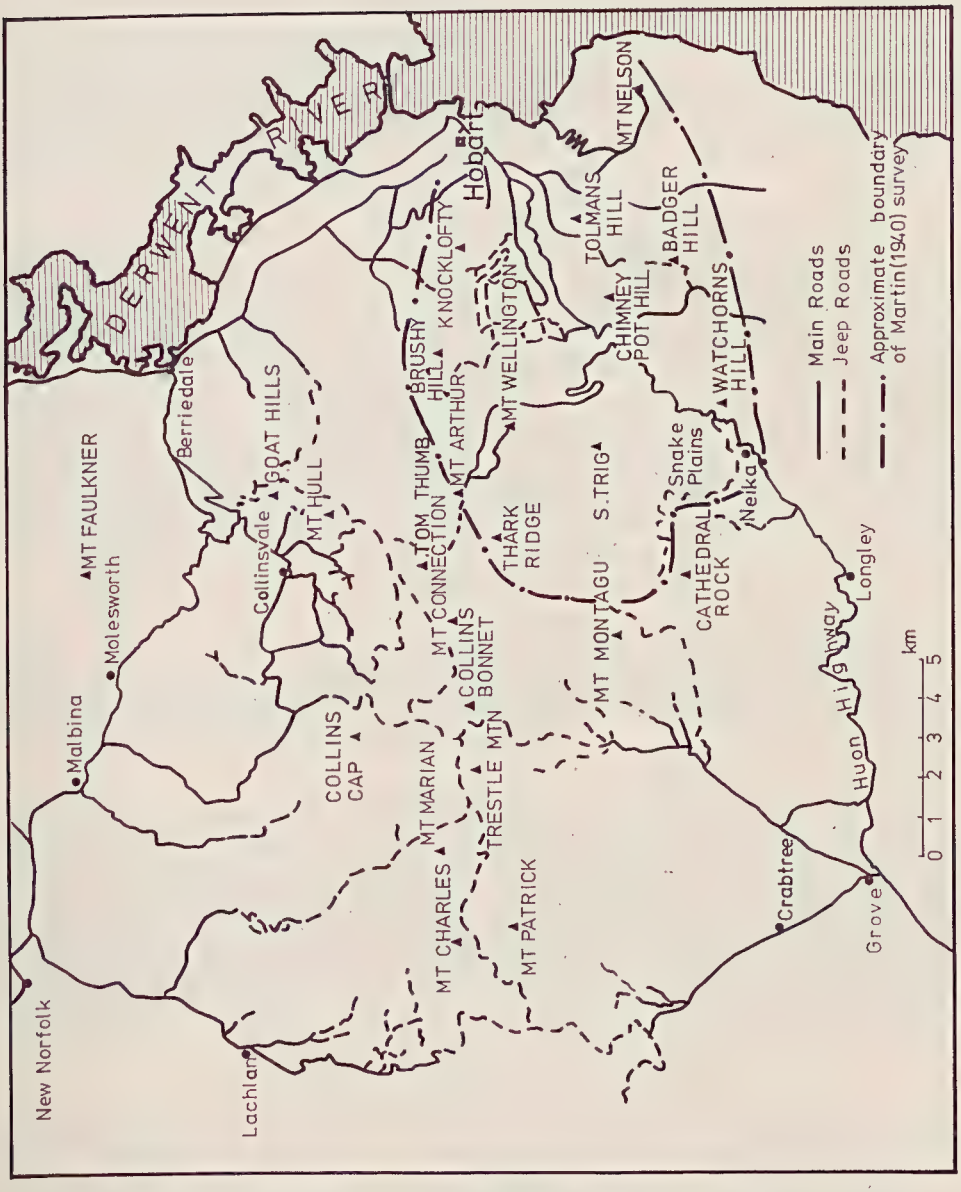

FIG. 1. - Map of the Mt. Wellington Range, showing the survey area.

'Dead Island' is found, upon which *E. coccifera* can grow. Similar to zone 1, there are two distinct regions within this zone, namely (i) wet, grassy areas, and (ii) rocky, shrubby areas. Species common throughout both regions of the zone are the fern *Gleichenia circinnata*, the monocotyledons *Calorophus minor, Astelia alpina, Poa gunnii, Schoenus calyptratus*, the shrubs *Baeckia gunniana, Sprengelia incarnata*, the dwarf perennial *Rubus gunnianus*, and the dicotyledonous herbs *Celmisia longifolia, Helichrysum scorpioides, Viola hederacea*. Species common only in the wet, grassy areas are the monocotyledons *Restio australis, Carpha alpina, Oreobolus oxycarpus* and the dicotyledonous herbs *Ourisia integrifolia, Epilobium gunnianum, Craspedia alpina, Haloragis micrantha*. Species common only in the rocky areas are the shrubs *Helichrysum ledifolium, Orites revoluta, Monotoca empetrifolia, Bauera rubioides, Epacris serpyllifolia*, and the herbs *Haloragis montana, Scaevola hookeri, Euphrasia diemenica, Geranium potentilloides, Plantago tasmanica*.

Zone 3a - *Eucalyptus urnigera* dominant

Below 1100 m to elevations down to as low as 760 m in some parts of the survey zone, the dominant species of eucalypt is the urn gum *E. urnigera*, which either forms pure stands or is accompanied by *E. coccifera* at the upper levels of the zone, and by *E. johnstonii* and *E. delegatensis* in the middle and lower levels of the zone, respectively. Similar to zones 1 and 2, there are wet, grassy areas within the zone (e.g. Midsky Swamp, Georges Flagland, marsh at head of Mountain River, Fools Tarn) as well as rocky, shrubby areas. Species common only in the wet, grassy areas are the fern *Gleichenia circinnata*, the monocotyledons *Calorophus minor, Astelia alpina, Carpha alpina, Restio australis, Oreobolus oxycarpus, Scirpus aucklandicus*, the shrubs *Baeckia gunniana, Sprengelia incarnata, Epacris serpyllifolia, Helichrysum hookeri*, the dicotyledonous herbs *Helichrysum scorpioides, Craspedia alpina, Celmisia longifolia, Haloragis micrantha*. Species common only in the rocky regions are the shrubs *Oxylobium ellipticum, Veronica formosa, Bauera rubioides* and the herbs *Haloragis montana* and *Hydrocotyle sibthorpioides*.

Zone 3b - *Eucalyptus delegatensis* dominant

In some portions of the survey zone (e.g. on Mt. Hull; at the upper (southern) end of the Lenah Valley Track; above Crabtree; above Collinsvale) large areas of pure or almost pure *E. delegatensis* occur, usually at elevations between 600-800 m. The frequency of species is given in the survey table in the Appendix.

Zone 4 - *Eucalyptus obliqua* dominant

The stringybark *E. obliqua* has a wide distribution throughout this zone, extending from the lower limit of elevation used in this survey (240 m) to an elevation of about 670 m, above which it seldom appears and is replaced by *E. delegatensis*, although the latter species can occur down to levels as low as 300 m. The mountain ash *E. regnans* attains its greatest frequency on the shadier, moister slopes of the mountain, e.g. near Neika and on the margins of gullies. A distinct region to be observed within this zone are the mudstone outcroppings where *E. tenuiramis* replaces *E. obliqua* as the dominant eucalypt. Other plants which reach great abundance on mudstone include the shrubs *Aotus ericoides, Pultenaea gunnii* var. *baeckioides, Acacia botrycephala, Daviesia ulicifolia, Leucopogon collinus*, the undershrubs *Tetratheca glandulosa, Amperea xiphoclada*, and the twining perennial *Cassytha pubescens*.

Zone 5 - Sandstone communities, *Eucalyptus johnstonii* dominant

The main areas of exposed sandstone occur at elevations of approximately 600-750 m and include such features as Snake Plains, The Springs, Sphinx Rock, as well as a variety of other outcroppings along the 'Pipeline Track' to Wellington Falls and in the vicinity of Collins Cap. The striking feature of these areas is the dominance, amongst eucalypts, of the yellow gum *E. johnstonii*. The abundance of species present at Snake Plains is somewhat different from those at the other areas of exposed sandstone, owing to the fact that the Plains are very flat and poorly drained, resulting in an acid, peaty soil. The following species are locally common at Snake Plains, but are absent at the other areas of sandstone: *Calorophus minor, Epacris lanuginosa,*

Melaleuca squamea, and the small prostrate species *Coprosma moorei* and *Boronia parviflora*.

Zone 6 - Gully communities

The bottom of gullies in sheltered areas at elevations up to 600 m that remain permanently wet have developed a dominant gully flora, the main species being *Olearia argophylla*, *Pomaderris apetala*, *Bedfordia salicina*, and to a somewhat lesser extent *Nothofagus cunninghamii*, *Atherosperma moschatum*. There is a large variety of fern species in the gully flora, including the tree fern *Dicksonia antarctica*; see Appendix.

Zone 7 - Dry sclerophyll forest

The lower slopes and foothills of Mt. Wellington consist either of mudstone or dolerite ridges which receive a comparatively low annual rainfall (600-750 mm). The dominant eucalypt of the mudstone ridges is *E. tenuiramis*, and there is a plant community associated with mudstone, in which certain species are locally abundant there, but of minor importance in the dolerite regions. These include the shrubs *Aotus ericoides*, *Pultenaea gunnii* var. *baeckioides*, *Acacia myrtifolia* and the undershrubs *Tetratheca glandulosa*, *Amperea xiphoclada*. In the dolerite section of the zone, the predominant eucalypt species are *E. pulchella* and *E. viminalis* in the drier areas, and *E. obliqua* and *E. globulus* in the wetter areas. Certain other plants are common throughout the entire zone. These include the monocotyledons *Themeda australis*, *Schoenus apogon*, *Lomandra longifolia*, *Diplarrhena moraea*, *Stipa pubinodis*, *Dichelachne sciurea*, *Danthonia setacea*, the shrubs *Epacris impressa*, *Astroloma humifusum*, *Pultenaea juniperina*, *Acacia dealbata*, *Leptospermum scoparium*, and the dicotyledonous herbs *Haloragis tetragyna*, *Viola hederacea*.

CENSUS OF THE PLANTS

The results of the survey are reported in the Appendix in the form of a census, the abundance of each native species being given for each zone in which it was found to occur (a list of introduced plants, not claimed to be complete, is also included). The sources of plant nomenclature and the meanings of the measures of abundance are given in the introduction to the Appendix.

COMPARISON WITH EARLIER SURVEY

Tables 1 and 2 compare various aspects of the present survey with that of Martin (1940). Table 1 contrasts the number of species reported in the two surveys, and in the case of Martin (1940), the tabulation is restricted to those actually observed by that author, and do not include the records of other collectors which he marked with an asterisk in his table. Many of these plants occur in coastal situations and/or at elevations below 240 m and the present authors feel justified in confining the comparison to those plants actually observed by Martin himself. Table 1 shows that

TABLE 1

NUMBER OF SPECIES REPORTED IN SURVEY

	Martin (1940)	The present study
Dicotyledoneae	247	313
Monocotyledoneae	84	137
Pteridophyta	39	35
Gymnospermae	2	2
Total	372	487

a considerably larger number of dicotyledons and monocotyledons have been observed in the present survey than in the earlier one. There are several reasons for the greater numbers in the present survey, e.g. the larger extent of the area surveyed, the greater frequency of visits by the present authors, and changes in nomenclature, which now recognize several taxa where earlier botanical works regarded several species as one taxon. Nevertheless, in spite of the increased numbers of species recorded in the present survey, there were 44 species reported by Martin (1940) but not seen by the present authors. Table 2 lists the discrepancies in the records of the two surveys under six subheadings, these being (a) species listed by Martin as occasional or frequent, but not observed in the present survey, (b) species listed by Martin as rare or very rare, and hence whose absence at present must be viewed as being of little consequence, (c) species listed by Martin which are believed by us to be possible mistaken identities, (d) species listed by Martin as frequent or common, but whose abundance at present is much less, (e) species absent from Martin's list but abundant at present, and (f) species whose abundance at present is much greater than in Martin's list. Comments are included in Table 2 in some cases either to help clarify discrepancies or to indicate changes in nomenclature.

TABLE 2

DISCREPANCIES IN RECORDS OF MARTIN (1940) AND THOSE OF THE PRESENT SURVEY

(a) Species listed by Martin as occasional or frequent, but not observed at present. Numbers refer to zones.

Name	Martin record	Comment
Acianthus caudatus	4:*f*;7:*o*	
A. viridis	4:*f*;7:*o*	
Asplenium flaccidum	6:*o*	
Blechnum patersonii	6:*o*	
Caladenia angustata	4:*o*	
C. dilatata	4:*o*;7:*f*	
Caleana minor	7:*o*	
C. major	7:*o*	
Centrolepis strigosa	5:*o*	
Epacris microphylla	7:*o*	
Goodia lotifolia	4:*o*	
Hibbertia fasciculata	5:*o*;7:*f*	
H. procumbens	7:*o*	
Lepidosperma squamata	4,5:*o*;7:*f*	
Leptospermum flavescens	4,5:*f*;7:*o*	
Lycopodium deuterodensum	1:*o*;6:*f*	
L. laterale	1:*f*	
Pleurosorus rutifolius	4,6:*o*	
Prasophyllum australe	7:*o*	
P. fuscum	1,4,7:*o*	
P. nigricans	7:*o*	
Schoenus tenuissimus	5:*o*	
Selaginella uliginosa	1:*f*;2:*o*	
Senecio velleioides	4:*o*	Often becomes more frequent after fires (Curtis 1963)
Thysanotus patersonii	7:*o*	
Thelymitra carnea	7:*o*	

(b) Species listed by Martin as rare or very rare, but not observed at present

Name	Martin Record	Comment
Anogramma leptophylla	1:*r*;4:*vr*	
Centrolepis fascicularis	5,7:*r*	
Cyrtostylis reniformis	7:*r*	Syn. *Acianthus reniformis*
Doodia caudata	2,3:*r*	
Eriochilus cucullatus	7:*r*	
Grevillea australis	2,3:*vr*	
Lyonsia straminea	4,6:*r*	Syn. *Parsonia straminea*
Microlaena tasmanica var. *subalpina*	1:*vr*	
Ozothamnus gunnii	1:*r*	Syn. *Helichrysum gunnii*, believed to be confined to the northeast and Flinders Island
Prasophyllum elatum	7:*r*	
Pultenaea tenuifolia	7:*vr*	
Spiranthes australis	7:*vr*	Syn. *S. sinensis*

(c) Species listed by Martin thought by the present authors to be possible mistaken identities

Name	Martin record	Comment
Brachyloma daphnoides	7:*f*	Not a Tasmanian species
Cyathodes acerosa	2,5,7:*o*;3,4:*c*	Syn. *C. juniperina*, but this species does not occur on Mt. Wellington (Curtis 1963)
Erythraea australis	4:*o*	Probably mistaken for *Centaurium erythraea* (see introduced species list)
Hakea sericea	3:*c*;4:*o*	Confined in Tasmania to islands of the Furneaux Group; probably *H. lissosperma* is meant
Olearia hookeri	7:*o*	Probably *O. ericoides* is meant (see Appendix)
Richea acerosa	1:*vc*;2:*c*	There is no other record from Mt. Wellington for this species and no herbarium material from this location

(d) Species listed by Martin as frequent, common or very common, but much less frequent at present

Name	Martin record	Present record
Dillwynia cinerascens	4:*o*;7:*f*	7:*l*
D. sericea	4:*o*;7:*c*	7:*l*
Kennedia prostrata	7:*c*	7:*r*
Orites acicularis	1:*vc*;2:*c*	1,2:*o*
Richea gunnii	1,2:*c*;3:*o*	2:*r*
Trochocarpa thymifolia	1,2:*vc*;3:*f*	1:*l*;2:*o*;3a:*vr*

(e) Species not observed by Martin, but frequent or common at present

Name	Martin record	Present record
Asperula gunnii	-	1:*f*
A. scoparia	-	7:*f*
Brachycome scapiformis	-	1,2,3:*f*;7:*c*
Hydrocotyle javanica	-	4,6:*c*
H. sibthorpioides	-	3a:*c*;3b:*f*
Leptorhynchos squamatus	-	7:*c*
Leucopogon collinus	-	7:*c*
Poranthera microphylla	-	3a,3b,4,7:*f*

(f) Species listed by Martin as rare or locally common, but more frequent at present

Name	Martin record	Present record
Australina pusilla	4,6:*r*	6:*c*
Cotula filicula	1:*r*	1,2,3a,3b,4,5:*o*
Gnaphalium spp.	1,2,4,5:*r*	1,2,3b,4,5,6:*o*;3a,7:*f*
Lagenophora stipitata	7:*r*	4,7:*f*
Pteridium esculentum	3,7:*lc*	3b,4,7:*c*;5:*f*
Scaevola hookeri	1:*r*	1:*f*;2,3a:*c*
Uncinia riparia	6:*r*	6:*f*

DISCUSSION

The major discrepancies between the two surveys, detailed in Table 2, could be of interest to ecologists who require information on the effect of fire on plant extinction or speed of plant regrowth or recovery after bushfires. It appears to be general that species of the genus *Richea* are making a slow recovery from the fire of 1967, and will not achieve their former abundance for some time. Ferns and fern allies are another group of plants whose abundance is generally less than during the time of Martin (1940). Not only are the number of species less than in the former survey, but of the 35 reported here, 9 of them are given as very rare. Although some species of ferns are amongst the first vascular plants to start regrowing after a fire, it appears that other species recover very slowly.

In spite of inevitable changes in abundances which reflect differences in seed dispersal and seedling establishment, the most encouraging finding of the present survey is the indication that a large number of species are still to be found in the Wellington Range. The total number of angiosperms found in the present survey was 450 (Table 1). This is more than one-third of the estimated 1200 native flowering species in Tasmania. Although the latter figure (Curtis 1969) is probably an underestimate, the fact that such a high proportion of the flora of the island is to be found on the Wellington Range eight years after a devastating fire is a tribute to the adaptability of the flora to fire.

Devasting fires occurred on Mount Wellington in 1898 and 1914. Other less serious fires have occurred periodically since settlement by European man, and it is reasonable to assume that the mountain was burnt in past millennia by Aboriginal man. Most species possess adaptations which favour the plants' survival or regeneration after fire. It is believed that fire has long been an important element in determining the structure and distribution of plant communities in Tasmania (Jackson 1968). Thus it is possible that the fire of 1967, destructive as it was, may not produce

significant long term changes in the distribution of communities or their species composition.

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APPENDIX

The following table has been compiled from observations between February 1973 and March 1975. The eight columns refer to the vegetation zones which are described in detail in the text. They are summarized below:

Zone 1 = Summit plateau
2 = *Eucalyptus coccifera* dominant
3a = *Eucalyptus urnigera* dominant
3b = *Eucalyptus delegatensis* dominant
4 = *Eucalyptus obliqua* dominant
5 = Sandstone communities, *E. johnstonii* dominant
6 = Gully communities
7 = Dry sclerophyll forest

Abundances of species in a particular zone are indicated by various abbreviations which are as follows:

c = common, i.e. abundant throughout zone
lc = locally common, i.e. abundant only in certain evironments within the zone
f = frequent
o = occasional
l = local, i.e. found in only a few localities within the zone, but neither sufficiently abundant to be called locally common, nor sufficiently sparse to be called rare
r = rare
vr = very rare

The following sources of botanical nomenclature have been used. Gymnosperms and dicotyledons: Curtis and Morris (1975), Curtis (1963 and 1967); Pteridophytes: Willis (1970); Grasses: Townrow (1969 and 1970), Vickery (1939, 1940, 1941, 1956 and 1970); Monocotyledons except grasses: Willis (1970), Black (1960), and the authors' own unpublished keys. In addition, the helpful assistance of the following people is gratefully acknowledged: Dr. W.M. Curtis (Hobart), Mr. D.I. Morris (Hobart) Mrs. J.E.S. Townrow (Hobart), Dr. L.A.S. Johnson (Sydney). Dr. E. Edgar (Christchurch) and Mr. R.J. Chinnock (Adelaide).

MONOCOTYLEDONEAE

	Zones							
	1	2	3a	3b	4	5	6	7
Gramineae (Poaceae)								
Agrostis parviflora[1] R.Br.	o	o	o	o	o	l	r	
A. venustra Trin.	o	o	o		r			
A. avenacea J.F.Gmel.				r	o		r	o
A. aemula R.Br.			o	o	o		o	o
Agropyron scabrum (Labill.) Beauv.								vr
Amphibromus archeri (Hook.f.)P.F.Morris								vr
Danthonia semiannularis (Labill.) R.Br.								vr
D. pauciflora R.Br.	o	vr						
D. purpurascens J.W.Vickery	r	o	f	o	o			o
D. setacea R.Br.					o		l	c
D. caespitosa Gaud.			vr		o		o	o
D. procera J.W.Vickery								r
D. laevis J.W.Vickery			r		r		o	o
D. pilosa[2] R.Br.			o	o	o	l	r	f
D. dimidiata J.W.Vickery					l			l
Deyeuxia quadriseta (Labill.) Benth.				o	o	l	r	o
D. monticola (Roem. & Schult.) J.W.Vickery	o	f	f	f	f	o	o	
D. rodwayi J.W.Vickery				o	o		r	
D. accedens J.W.Vickery		vr	r	o	o		o	
D. benthamiana J.W.Vickery				r	o			
D. scaberula J.W.Vickery				o	o	l	o	
D. sp.aff.*microseta*[3] J.W.Vickery	l	l	l					
Dichelachne sciurea (R.Br.) Hook.f.				lc	f	l	r	c
D. crinita (L.f.) Hook.f.					r			o
Distichlis distichophylla (Labill.) Fassett					l			lc
Echinopogon ovatus (Forst.f.) Beauv.			l	o	o		r	r
Festuca asperula[4] J.W.Vickery		r	o	o	o	r		o
Hierochloe redolens (Soland.) Roem. & Schult.	f	f	f	o	r	r	r	
H. fraseri Hook.	o	o						
Microlaena stipoides (Labill.) R.Br.				r	o		r	o
Pentapogon quadrifidus (Labill.) Baill.			o	o	o			r
Poa australis[5] sp.agg.	c	c	c	c	c			c
P. saxicola R.Br.		f	f	o				
Stipa aphylla (Rodway) Townrow								r
S. mollis R.Br.								o
S. pubinodis Trin. & Rupr.					r			c
Tetrarrhena distichophylla (Labill.) R.Br.								o
Themeda australis (R.Br.) Stapf								c
Cyperaceae								
Carex appressa R.Br.	f	f	f	f	l	r	c	r
C. archeri Boott	vr	vr	vr					
C. breviculmis R.Br.		f	lc	l	o			f
C. curta Gooden.					l			r
C. gaudichaudiana Kunth		l	l	l				
C. gunniana Boott			l	l				
C. inversa R.Br.				r				
C. inyx Nelmes								vr
C. longibrachiata Boeck.					vr			
Carpha alpina R.Br.	f	f	f	o				

Change in abundance of vascular plants on Mt. Wellington following fire

	Zones							
	1	2	3a	3b	4	5	6	7
Cyperus tenellus L.f.					*vr*			
Eleocharis acuta R.Br.					*vr*			
Gahnia graminifolia Rodway								*f*
G. grandis[6] (Labill.) S.T. Blake	*r*	*o*	*f*	*f*	*c*	*c*	*c*	*o*
G. radula (R.Br.) Benth.					*l*			*o*
Lepidosperma elatius Labill.					*o*		*o*	*o*
L. filiforme Labill.		*lc*	*lc*		*l*			*lc*
L. laterale R.Br.					*lc*			*lc*
L. lineare[7] R.Br.								*f*
Oreobolus distichus F.Muell.	*r*	*lc*	*lc*					
O. oxycarpus S.T.Blake		*lc*	*lc*					
O. pumilio R.Br.	*o*	*f*						
Schoenus apogon Roem. & Schult.			*r*	*o*	*f*		*f*	*c*
S. calyptratus Kükenthal & Blake	*o*	*c*	*o*					
S. maschalinus Roem. & Schult.					*l*			*l*
Scirpus antarcticus L.					*o*			*o*
S. aucklandicus (Hook.f.) Boeck.	*l*	*lc*	*lc*	*lc*	*lc*	*lc*	*l*	
S. crassiusculus (Hook.f.) Benth.	*lc*	*lc*						
S. fluitans L.			*r*	*r*	*l*			*l*
S. hookeranus (Boeck.) S.T. Blake			*l*		*l*	*r*	*l*	*o*
S. inundatus (R.Br.) Spreng.			*l*	*l*	*l*		*o*	*l*
S. platycarpus S.T.Blake				*r*	*l*		*l*	*o*
S. subtilissimus (Boeck.) S.T.Blake	*l*	*lc*	*lc*	*l*	*l*	*l*	*l*	
S. wakefieldianus S.T.Blake					*l*		*l*	
Tetraria capillaris (F.Muell.) J.M.Black					*l*			*vr*
Uncinia compacta R.Br.	*o*	*o*	*o*	*r*				
U. riparia R.Br.					*o*		*f*	
U. tenella R.Br.			*vr*	*vr*	*o*		*c*	
Restionaceae								
Calorophus minor[8] Hook.f.	*c*	*c*	*lc*	*r*	*l*	*f*		
Lepyrodia tasmanica Hook.f.			*l*			*lc*		
Restio australis R.Br.	*lc*	*lc*	*lc*					
Centrolepidaceae								
Centrolepis aristata Roem. & Schult.								*vr*
C. monogyna Benth.		*lc*	*o*					
Juncaceae								
Juncus australis Hook.f.				*l*	*l*	*o*		
J. gregiflorus L.Johnson					*lc*	*lc*		*lc*
J. holoschoenus R.Br.				*r*	*o*			*o*
J. pallidus R.Br.			*l*	*l*	*lc*	*o*		*lc*
J. planifolius R.Br.				*lc*	*lc*	*lc*	*lc*	*r*
J. procerus E.Mey.				*lc*	*lc*	*lc*		*lc*
J. pauciflorus R.Br.			*r*	*l*	*o*	*r*	*o*	
J. sandwithii Lourt.	*lc*	*l*	*l*	*l*	*o*	*l*		*l*
J. subsecundus N.A.Wakefield			*lc*	*lc*	*lc*			*lc*
J. sarophorus L.Johnson			*vr*	*lc*	*lc*	*lc*		*lc*
J. sp.aff. *sandwithii*[9] Lourt.		*lc*	*lc*					
Luzula sp.agg. [10]	*c*	*c*	*f*	*f*	*c*	*c*	*f*	*c*

	Zones							
	1	2	3a	3b	4	5	6	7
Liliaceae								
Anguillaria dioica R.Br.								*o*
Arthropodium milleflorum (DC.) Macbride					*r*			*f*
Astelia alpina R.Br.	*c*	*c*	*lc*	*r*				
Bulbine bulbosa (R.Br.) Haw.								*o*
B. semibarbata (R.Br.) Haw.					*l*	*vr*		
Dianella revoluta R.Br.					*o*			*o*
D. tasmanica Hook.f.				*c*	*f*	*o*		*o*
Drymophila cyanocarpa R.Br.		*r*	*o*	*o*	*o*	*o*	*f*	*o*
Laxmannia sessiliflora Decaisne								*l*
Lomandra logifolia Labill.				*vr*	*o*			*c*
Stypandra caespitosa R.Br.								*r*
Hypoxidaceae								
Hypoxis hygrometrica Labill					*r*			*o*
Iridaceae								
Diplarrhena moraea Labill.				*o*	*o*			*c*
Orchidaceae								
Caladenia carnea R.Br.				*o*	*o*			*o*
C. cucullata R.D.FitzG.					*r*			*r*
C. gracilis R.Br.					*o*			*o*
C. lyallii Hook.f.	*r*	*f*	*o*	*o*	*o*	*r*		
C. patersonii R.Br.								*l*
Calochilus robertsonii Benth.					*o*			*r*
Chiloglottis cornuta Hook.f.							*l*	
C. gunnii Lindl.		*vr*	*vr*	*lc*	*lc*	*f*	*o*	*l*
Dipodium punctatum (Sm.) R.Br.								*vr*
Diuris maculata Sm.					*l*			*l*
D. pedunculata R.Br.								*l*
D. sulphurea R.Br.								*l*
Gastrodia sesamoides R.Br.		*vr*	*vr*	*r*	*o*		*r*	*r*
Glossodia major R.Br.								*o*
Lyperanthus suaveolens R.Br.								*r*
Microtus parviflora R.Br.				*o*	*o*		*r*	*o*
Prasophyllum alpinum R.Br.	*o*	*o*	*o*					
P. brevilabre (Lindl.) Hook.f.								*r*
P. suttonii R.S.Rogers & B.Rees		*l*						
Pterostylis alpina R.S.Rogers	*o*	*o*	*o*			*o*		
P. decurva R.S.Rogers			*l*	*vr*				*l*
P. longifolia R.Br.				*l*	*o*			*o*
P. nana R.Br.					*r*			*r*
P. nutans R.Br.			*l*	*l*	*l*	*l*	*l*	*l*
P. pedunculata R.Br.								*l*
Thelymitra grandiflora R.D.FitzG.					*r*			*o*
T. ixioides Swartz					*o*			*o*
T. nuda R.Br.								*o*
T. pauciflora R.Br.				*o*	*o*	*vr*		*o*
T. venosa R.Br.		*lc*	*lc*			*lc*		

Change in abundance of vascular plants on Mt. Wellington following fire

	Zones							
	1	2	3a	3b	4	5	6	7
Typhaceae								
Typha orientalis Presl					*l*			*l*
DICOTYLEDONEAE								
Ranunculaceae								
Clematis aristata R.Br. ex DC.		*vr*	*vr*	*o*	*o*		*f*	*o*
C. gentianoides DC.								*o*
Ranunculus lappaceus Sm.					*o*			*c*
R. scapigerus Hook.		*o*	*c*	*c*	*f*	*o*		
R. collinus R.Br. ex DC	*o*	*lc*	*c*	*o*	*r*			
R. pumilio R.Br. ex DC.				*vr*	*r*			*vr*
Dilleniaceae								
Hibbertia hirsuta (Hook.) Benth.								*f*
H. riparia (R.Br. ex DC.) Hoogl.					*l*			*c*
H. empetrifolia (DC.) Hoogl.		*l*	*l*	*lc*	*l*			
Winteraceae								
Drimys lanceolata (Poir.) Baill.	*o*	*o*	*o*	*o*	*o*		*o*	
Cruciferae (Brassicaceae)								
Rorippa dictyosperma (Hook.) L.Johnson				*o*	*o*		*r*	
Cardamine heterophylla Hook.	*o*	*o*	*o*	*o*	*l*		*vr*	*r*
Violaceae								
Viola hederacea Labill.	*c*	*c*	*c*	*c*	*c*	*lc*	*c*	*c*
Pittosporaceae								
Pittosporum bicolor Hook.		*r*	*o*	*o*	*o*	*o*	*f*	
Bursaria spinosa Cav.					*l*			*f*
Marianthus procumbens (Hook.) Benth.					*r*			*o*
Billardiera longiflora Labill.		*o*	*f*	*f*	*c*	*f*	*f*	*vr*
Tremandraceae								
Tetratheca glandulosa Labill.					*lc*			*lc*
T. pilosa Labill.				*lc*	*lc*			*c*
T. procumbens Gunn ex Hook.f.			*l*					
Polygalaceae								
Comesperma volubile Labill.					*f*			*c*
C. retusum Labill.			*r*			*o*		*l*

	Zones							
	1	2	3a	3b	4	5	6	7
Caryophyllaceae								
Stellaria flaccida Hook.				*l*	*o*		*c*	
Scleranthus biflorus (J.R. & G. Forst.) Hook.f.	*vr*	*vr*	*o*					*r*
Portulacaceae								
Calandrinia calyptrata Hook.f.								*vr*
Neopaxia australasica (Hook.f.) Ö.Nilss.			*lc*	*lc*	*l*			
Hypericaceae								
Hypericum gramineum Forst.f.					*lc*			*o*
H. japonicum Thunb. ex Murr.			*r*	*r*				
Malvaceae								
Asterotrichion discolor (Hook.) Melville			*r*	*r*	*f*		*f*	*o*
Elaeocarpaceae								
Aristotelia peduncularis (Labill.) Hook.f.		*o*	*o*	*o*	*f*	*r*	*f*	*vr*
Linaceae								
Linum marginale A.Cunn.								*c*
Geranicaceae								
Geranium potentilloides L'Hérit. ex DC.	*c*	*c*	*c*	*c*	*c*	*lc*		*c*
G. solanderi Carolin					*l*		*vr*	*o*
Pelargonium inodorum Willd.			*o*	*o*	*f*	*r*	*r*	*o*
Oxalidaceae								
Oxalis lactea Hook.		*r*	*o*	*o*	*o*		*o*	
O. corniculata L.			*vr*		*f*		*o*	*c*
Rutaceae								
Zieria arborescens Sims.					*f*	*f*	*f*	
Boronia pilosa Labill.					*l*			*lc*
B. nana Hook.								*r*
B. parviflora Sm.					*l*	*lc*		
Eriostemon verrucosus A.Rich.								*l*
Phebalium squameum (Labill.) Engler		*l*	*l*	*o*	*lc*	*c*	*c*	
Correa reflexa (Labill.) Vent				*r*	*f*	*o*	*o*	*f*
C. lawrenciana Hook.			*f*	*f*	*f*	*o*	*o*	
Stackhousiaceae								
Stackhousia monogyna Labill.			*r*	*o*	*o*			*f*

Change in abundance of vascular plants on Mt. Wellington following fire

	Zones							
	1	2	3a	3b	4	5	6	7
Rhamnaceae								
Pomaderris elliptica Labill.					o			lc
P. apetala Labill.				f	c	o	c	r
Spyridium ulicinum (Hook.) Benth.			lc	l	l			
Sapindaceae								
Dodonaea viscosa Jacq.								r
Mimosoideae (Mimosaceae)								
Acacia genistifolia Link					o			c
A. verticillata (L.Hérit.) Willd.				r	f			f
A. riceana Henslow		l	l	o	f		o	f
A. gunnii Benth.								r
A. verniciflua A.Cunn.					c		o	lc
A. stricta (Andr.) Willd.					lc			c
A. myrtifolia (Sm.) Willd.					o			c
A. melanoxylon R.Br.				o	f	r		f
A. botrycephala (Vent.) Desf.					lc			lc
A. mearnsii De Wild.		vr		r	f	r	f	o
A. dealbata Link			r	o	c	r	f	c
Papilionatae (Fabaceae)								
Oxylobium arborescens R. Br.				vr				
O. ellipticum (Labill.) R.Br.		o	f	c	c	c		lc
Sphaerolobium vimineum Sm.								o
Daviesia latifolia R.Br.					l			l
D. ulicifolia Andr.					f			c
Aotus ericoides (Vent.) G.Don					lc			lc
Pultenea daphnoides [11] Wendl.					f			f
P. stricta Sims.					c			lc
P. gunnii[12] Benth.				l	lc			lc
P. pedunculata Hook.					l			l
P. subumbellata Hook.				vr	vr			
P. juniperina Labill.		l	f	f	c			c
Dillwynia sericea A.Cunn.								l
D. cinerascens R.Br.								l
Bossiaea prostrata R.Br.					r			c
Hovea heterophylla A.Cunn. ex Hook.f.								f
Goodia pubescens Sims.					vr			
Indigofera australis Willd.					r			o
Kennedia prostrata R.Br.								r
Rosaceae								
Rubus gunnianus Hook.		f	c	c				
R. parvifolius L.					r			r
Acaena ovina [13] A.Cunn.					o			c
A. novae-zelandiae Kirk		f	f	f	c	c	f	c	c
A. montana Hook.f.		o	o					

	Zones							
	1	2	3a	3b	4	5	6	7
Cunoniaceae								
Bauera rubioides Andr.		*c*	*c*	*o*	*l*	*c*		
Escalloniaceae								
Anopterus glandulosus Labill.				*r*			*r*	
Tetracarpaea tasmanica Hook.f.		*r*	*vr*					
Crassulaceae								
Crassula sieberana (Schult. & Schult.f.) Druce		*r*	*o*	*o*		*o*		*o*
Droseraceae								
Drosera arcturi Hook.	*c*	*c*						
D. pygmaea DC.	*f*	*f*	*l*	*l*	*l*			
D. binata Labill.				*vr*				
D. auriculata Backh. ex Planch.				*f*	*f*		*l*	*f*
D. gracilis Hook.f. ex Planch.			*r*					
Haloragaceae								
Haloragis micrantha (Thunb.) R.Br.		*c*	*lc*	*r*	*r*	*o*		*l*
H. tetragyna (Labill.) Hook f.							*l*	*c*
H. teucrioides DC.				*c*	*c*	*f*	*f*	*c*
H. montana Hook.f.	*c*	*c*	*c*					
Myriophyllum pedunculatum Hook.f.		*r*	*l*					
Myrtaceae								
Baeckea gunniana Schauer ex Walp.	*c*	*c*	*lc*					
Leptospermum scoparium J.R. & G. Forst.				*f*	*f*	*c*		*c*
L. lanigerum (Ait.) Sm.		*f*	*c*	*f*	*f*	*c*	*o*	
L. rupestre Hook.f.	*lc*	*o*						
Callistemon pallidus (Bonpl.) DC.		*r*	*lc*	*vr*	*o*			*o*
C. viridiflorus (Sims.) Sweet			*l*		*r*			
Melaleuca squarrosa Donn ex Sm.					*l*			*vr*
M. squamea Labill.			*lc*	*r*	*r*	*lc*		
Eucalyptus ovata Labill.								*lc*
E. viminalis Labill.					*o*			*c*
E. rubida Deane & Maiden					*l*			
E. urnigera Hook.f.			*c*	*o*	*r*	*o*		
E. cordata Labill.								*l*
E. globulus Labill.					*o*		*r*	*c*
E. johnstonii Maiden			*o*	*o*	*r*	*c*		
E. obliqua L'Hérit.				*r*	*c*		*l*	*lc*
E. regnans F.Muell.					*lc*		*o*	
E. delegatensis R.T.Baker			*o*	*c*	*o*	*o*		
E. pulchella Desf.				*vr*	*l*			*c*
E. amygdalina Labill.								*o*
E. coccifera Hook.f.		*c*	*c*					
E. tenuiramis Miq.					*lc*			*lc*

Change in abundance of vascular plants on Mt. Wellington following fire

	Zones							
	1	2	3a	3b	4	5	6	7
Onagraceae								
Epilobium gunnianum[14] sp.agg.	*c*	*c*	*f*	*f*	*f*	*o*	*c*	*f*
E. rotundifolium[15] Forst.f.					*lc*		*lc*	
Umbelliferae (Apiaceae)								
Hydrocotyle sibthorpioides Lamk.	*lc*	*o*	*c*	*f*		*lc*		
H. javanica Thunb.				*o*	*c*	*o*	*c*	
Oreomyrrhis sessiliflora Hook.f.	*vr*							
Daucus glochidiatus (Labill.) Fisch. et al.								*r*
Rubiaceae								
Coprosma hirtella Labill.			*o*	*f*	*f*	*o*	*c*	*o*
C. quadrifida (Labill.) Robinson					*f*	*o*	*f*	*o*
C. nitida Hook.f.	*o*	*o*	*f*	*o*	*r*	*o*		
C. pumila Hook.f.	*l*	*l*						
C. moorei Rodway		*l*	*l*			*l*		
Opercularia varia Hook.f.					*o*			*f*
Galium gaudichaudii DC.					*l*			
G. australe DC.		*r*	*o*	*o*	*o*	*l*		
G. albescens Hook.f.				*l*	*l*			
Asperula scoparia Hook.f.				*l*	*o*			*f*
A. gunnii Hook.f.	*f*	*o*	*l*					
Compositae (Asteraceae)								
Lagenophora stipitata (Labill.) Druce		*r*	*l*	*o*	*f*	*r*	*vr*	*f*
L. huegelii Benth.					*vr*			*vr*
Brachycome decipiens Hook.f.								*o*
B. scapiformis DC.	*f*	*f*	*f*		*vr*			*c*
B. stricta DC.								*vr*
Olearia viscosa (Labill.) Benth.		*o*	*f*	*c*	*c*	*o*	*l*	*f*
O. argophylla F.Muell.				*o*	*c*	*r*	*c*	*r*
O. myrsinoides (Labill.) Benth.								*vr*
O. erubescens (DC.) Dippel		*o*	*c*	*f*	*f*	*o*		*f*
O. persoonioides (DC.) Benth.			*o*	*l*		*f*	*o*	
O. tasmanica[16] (Hook.f.) W.M.Curtis		*o*	*f*		*vr*			
O. obcordata (Hook.f.) Benth.	*l*	*lc*	*lc*					
O. pinifolia (Hook.f.) Benth.	*o*	*o*	*o*					
O. ledifolia (DC.) Benth.	*f*	*o*	*r*					
O. stellulata (Labill.) DC.					*f*	*f*	*o*	*o*
O. phlogopappa (Labill.) DC.	*r*	*o*	*f*	*c*	*c*	*c*	*o*	*vr*
O. ramulosa (Labill.) Benth.				*l*				*f*
O. ericoides (Steetz) N.A.Wakefield								*f*
O. floribunda (Hook.f.) Benth.		*l*	*lc*	*lc*	*o*	*f*		*f*
O. algida N.A.Wakefield	*o*	*o*	*o*			*o*		
O. glandulosa (Labill.) Benth.								*lc*
Celmisia longifolia Cass.	*c*	*c*	*c*	*vr*	*vr*	*f*	*vr*	
C. saxifraga Comber	*l*							
Erigeron pappochroma Labill.	*o*	*f*	*l*			*l*		
Vittadinia triloba (Gaud.) DC.								*r*
Gnaphalium involucratum Forst.f.					*r*		*l*	*o*
G. collinum Labill.		*o*	*f*	*o*	*o*	*o*	*o*	*f*

	Zones							
	1	2	3a	3b	4	5	6	7
G. umbricola J.H.Willis	*vr*	*l*	*l*	*l*	*r*			
G. traversii Hook.f.	*o*	*r*	*r*					
G. sp.[17]	*o*	*vr*	*vr*					
Ewartia planchonii (Hook.f.) Beauv.	*vr*	*l*						
Leptorhynchos squamatus (Labill.) Less.		*vr*			*o*			*c*
L. linearis Less.								*o*
Helichrysum scorpioides Labill.	*c*	*c*	*c*	*o*	*lc*	*o*	*r*	*c*
H. dealbatum Labill.					*vr*			*o*
H. apiculatum (Labill.) DC.			*r*	*r*	*o*	*r*		*lc*
H. semipapposum (Labill.) DC.		*vr*	*vr*	*r*				*c*
H. ledifolium (DC.) Benth.	*c*	*c*	*f*	*o*	*r*	*r*		*vr*
H. purpurascens (DC.) W.M.Curtis					*r*			o
H. rosmarinifolium (Labill.) Steud. ex Benth.			*l*	*l*		*r*		
H. dendroideum N.A.Wakefield					*c*	*o*	*f*	*f*
H. thyrsoideum (DC.) Willis & Morris			*o*	*f*	*f*	*o*	*r*	*r*
H. antennarium (DC.) F.Muell. ex Benth.		*r*	*o*	*o*	*o*	*r*	*r*	
H. obcordatum (DC.) F.Muell. ex Benth.					*r*	*vr*		*o*
H. backhousii[18] (Hook.f.) F.Muell. ex Benth.	*f*	*f*						
H. hookeri (Sond.) Druce	*f*	*f*	*o*	*vr*		*vr*		
H. expansifolium (Morris & Willis) N.T.Burbidge	*o*	*o*	*r*					
H. scutellifolium (Hook.f.) Benth.				*vr*	*r*			*r*
Cassinia aculeata R.Br.			*o*	*o*	*f*	*o*	*f*	*f*
Craspedia glauca (Labill.) Spreng.				*o*	*o*			*o*
C. alpina Backh. ex Hook.f.	*c*	*c*	*f*					
Podolepis jaceoides (Sims) Voss								*l*
Cotula filicula (Hook.f.) Benth.	*o*	*o*	*o*	*o*	*o*	*o*		
C. australis (Sieb. ex Spreng.) Hook.f.								*l*
Abrotanella forsterioides (Hook.f.) Benth.	*lc*	*lc*						
Senecio pectinatus[19] DC.	*o*	*lc*						
S. leptocarpus DC.		*o*	*l*					
S. brunonis[20] (Hook.f.) J.H.Willis		*vr*	*o*	*o*		*r*		
S. lautus sensu auct. Austral.		*o*	*o*	*o*	*f*			
S. linearifolius A.Rich.		*vr*	*f*	*c*	*c*	*o*	*c*	*f*
S. minimus Poir.		*r*	*o*	*o*	*f*		*f*	*o*
S. squarrosus A.Rich.					*o*			*o*
S. quadridentatus Labill.					*o*			*c*
S. gunnii (Hook.f.) Belcher	*f*	*f*	*o*					
S. glomeratus Desf. ex Poir.					*o*			*o*
S. hispidulus A.Rich.					*o*			*f*
Bedfordia salicina DC.		*vr*	*o*	*c*	*c*	*o*	*c*	*f*
B. linearis DC.								*lc*
Microseris scapigera (Sol.) Schultz-Bip.								*l*
Stylidiaceae								
Stylidium graminifolium Swartz				*l*	*f*	*f*		*f*
Goodeniaceae								
Goodenia ovata Sm.					*c*		*lc*	*c*
G. lanata R.Br.								*c*
Scaevola hookeri (de Vriese) Hook.f.	*f*	*c*	*c*	*vr*				

Change in abundance of vascular plants on Mt. Wellington following fire

	Zones							
	1	2	3a	3b	4	5	6	7
Campanulaceae								
Wahlenbergia gymnoclada N. Lothian				*vr*	*o*			*o*
W. consimilis N.Lothian				*l*	*o*		*r*	*f*
W. saxicola A.DC.	*l*	*f*	*o*					
Lobeliaceae								
Pratia pedunculata (R.Br.) Benth.								*vr*
Lobelia gibbosa Labill.				*vr*	*r*			*o*
Ericaceae								
Gaultheria hispida R.Br		*o*	*o*	*o*	*o*	*o*	*o*	
Epacridaceae								
Styphelia adscendens R.Br.					*l*			*r*
Astroloma humifusum (Cav.) R.Br.					*o*			*c*
Cyathodes glauca Labill.		*o*	*f*	*f*	*f*	*r*		*l*
C. straminea R.Br.	*vr*	*r*						
C. petiolaris (DC.) Druce	*lc*							
C. dealbata R.Br.	*o*							
C. divaricata Hook.f.				*r*	*r*			*l*
C. parvifolia R.Br.		*o*	*f*	*o*	*r*	*o*		
Pentachondra involucrata R.Br.		*o*	*o*	*o*				
P. pumila (Forst.) R.Br.	*f*	*l*						
Trochocarpa thymifolia (R.Br.) Spreng.	*l*	*o*	*vr*					
Lissanthe strigosa (Sm.) R.Br.								*c*
L. montana R.Br.	*o*	*r*						
Leucopogon collinus (Labill.) R.Br.					*lc*			*c*
L. virgatus (Labill.) R.Br.								*lc*
L. ericoides (Sm.) R.Br.				*l*	*l*			*lc*
Acrotriche serrulata (Labill.) R.Br.								*f*
Monotoca glauca (Labill.) Druce				*l*	*f*	*f*	*o*	*vr*
M. linifolia (Rodw.) W.M. Curtis				*l*		*l*		
M. empetrifolia R.Br.	*c*	*f*	*o*					
Epacris impressa Labill.				*f*	*c*	*f*	*vr*	*c*
E. lanuginosa Labill.						*lc*		
E. serpyllifolia R.Br.	*c*	*c*	*o*					
E. tasmanica [21] W.M. Curtis					*l*			
E. acuminata Benth.		*vr*	*lc*		*l*			
Sprengelia incarnata Sm.	*c*	*c*	*f*		*l*	*l*		
Richea sprengelioides (R.Br.) F.Muell.	*f*	*o*	*lc*					
R. procera (F.Muell.) F.Muell.		*l*	*lc*	*o*	*lc*	*c*		
R. gunnii Hook.f.		*r*						
R. scoparia Hook.f.	*f*	*o*	*lc*					
R. dracophylla R.Br.		*vr*	*o*	*o*	*o*	*f*		
R. curtisiae A.M. Gray		*vr*						
Oleaceae								
Notelaea ligustrina Vent.		*vr*	*o*	*o*	*o*			*o*

	Zones							
	1	2	3a	3b	4	5	6	7
Loganiaceae								
Mitrasacme montana Hook.f.	*f*	*o*	*r*	*vr*				
M. pilosa Labill.					*vr*			*vr*
Gentianaceae								
Sebaea ovata (Labill.) R.Br.					*r*			*o*
Gentianella diemensis (Griseb.) J.H. Willis	*f*	*f*	*o*	*l*	*f*			*o*
Boraginaceae								
Cynoglossum suaveolens R.Br.			*o*	*o*	*o*			*o*
C. australe R.Br.								*vr*
Myosotis australis R.Br.		*vr*	*o*	*o*			*r*	
Convolvulaceae								
Convolvulus erubescens Sims								*l*
Dichondra repens J.R. & G. Forst.								*vr*
Solanaceae								
Solanum laciniatum Ait.					*r*		*r*	*vr*
Scrophulariaceae								
Ourisia integrifolia R.Br.	*lc*	*lc*						
Veronica formosa R.Br.		*f*	*c*	*f*	*r*		*r*	*l*
V. derwentiana Andr.					*o*		*r*	*r*
V. nivea Lindl.		*o*	*o*		*vr*			
V. gracilis R.Br.					*o*			*lc*
V. calycina R.Br.			*vr*	*vr*				
V. serpyllifolia L.		*vr*	*l*	*o*	*f*	*r*	*f*	
Euphrasia collina R.Br.				*f*	*f*			*c*
E. diemenica Spreng.	*f*	*f*	*f*	*f*				
E. striata R.Br.	*f*	*f*	*lc*					
E. gibbsiae Du Rietz	*f*	*f*	*l*					
E. scabra R.Br.								*l*
Labiatae (Lamiaceae)								
Prunella vulgaris L.				*o*	*f*	*l*	*o*	*f*
Prostanthera lasianthos Labill.		*vr*	*o*	*f*	*f*	*r*	*c*	
Westringia angustifolia R.Br.				*l*	*l*			
Ajuga australis R.Br.								*r*
Plantaginaceae								
Plantago varia R.Br.					*l*			*c*
P. tasmanica Hook.f.	*c*	*c*	*c*	*f*				
P. daltonii Dcne.			*l*					

Change in abundance of vascular plants on Mt. Wellington following fire

	Zones							
	1	2	3a	3b	4	5	6	7
Polygonaceae								
Rumex brownii Campd.				*l*	*l*			*l*
Monimiaceae								
Atherosperma moschatum Labill.		*vr*	*r*	*r*	*r*	*r*	*f*	
Lauraceae								
Cassytha pubescens R.Br.					*lc*			*f*
Proteaceae								
Bellendena montana R.Br.	*f*	*r*	*vr*					
Persoonia juniperina Labill.								*l*
Orites diversifolia R.Br.		*o*	*c*	*f*				
O. revoluta R.Br.	*f*	*f*	*o*					
O. acicularis R.Br.	*o*	*o*						
Hakea epiglottis Labill.				*l*				*l*
H. lissosperma R.Br.		*o*	*o*	*o*	*o*	*r*		
Telopea truncata (Labill.) R.Br.		*o*	*o*	*r*		*r*	*r*	
Lomatia tinctoria R.Br.		*r*	*o*	*c*	*f*	*vr*		*c*
L. polymorpha R.Br.		*o*	*f*					
Banksia marginata Cav.			*f*	*o*	*o*	*o*		*c*
Thymelaeaceae								
Pimelea cinerea R.Br.			*r*	*r*	*r*	*r*		
P. linifolia Sm.					*l*	*vr*		*o*
P. humilis R.Br.								*c*
P. sericea R.Br.	*o*	*f*	*o*					
P. nivea Labill.		*l*	*l*	*f*	*lc*			*c*
P. drupacea Labill.		*vr*	*r*	*o*	*o*	*r*	*o*	
P. flava R.Br.					*l*			*l*
Santalaceae								
Leptomeria drupacea (Labill.) Druce					*vr*			*o*
Exocarpos cupressiformis Labill.					*o*			*f*
E. strictus R.Br.					*o*			*f*
E. humifusus R.Br.	*f*	*o*	*r*					
Euphorbiaceae								
Poranthera microphylla Brogn.			*f*	*f*	*f*	*o*	*o*	*f*
Beyeria viscosa Miq.					*o*		*l*	*o*
Amperea xiphoclada (Sieb. ex Spreng.) Druce				*r*	*lc*			*l* *c*
Phyllanthus australis Hook.f.					*lc*			*l*
Urticaceae								
Urtica incisa Poir.			*r*	*o*	*o*		*c*	
Australina pusilla Gaud.							*c*	
A. muelleri Wedd.							*l*	

	Zones							
	1	2	3a	3b	4	5	6	7
Casuarinaceae								
Casuarina stricta Ait.								o
C. littoralis [22] Salisb.		l	l		r			f
Fagaceae								
Nothofagus cunninghamii (Hook.) Oerst.		o	o	lc	r	vr	f	
PTERIDOPHYTA								
Schizaeaceae								
Schizaea fistulosa Labill.						o		
Gleicheniaceae								
Gleichenia circinnata [23] Swartz	lc	lc	lc	l	vr	o		
Sticherus tener (R.Br.) Ching				vr	vr		vr	
Hymenophyllaceae								
Mecodium flabellatum (Labill.) Copeland							o	
M. australe (Willd.) Copeland							o	
Hymenophyllum peltatum (Poir.) Desv.							vr	
Dicksoniaceae								
Dicksonia antarctica Labill.			o	o	f	r	c	vr
Dennstaedtiaceae								
Hypolepis rugosula (Labill.) J.Sm.		r	o	o	o	o	o	
H. australis N.A.Wakefield							c	
Pteridium esculentum (Forst.f.) Nakai			r	c	c	f	o	c
Histiopteris incisa(Thunb.) J.Sm.	vr	r	r	r	o	o	c	
Lindsayaceae								
Lindsaya linearis Swartz					vr			vr
Adiantaceae								
Adiantum aethiopicum L.								l
Cheilanthes tenuifolia (Burm.f.) Swartz								vr
Grammitidaceae								
Grammitis billardieri Willd.					r		o	
G. armstrongii M.D.Tindale		o	o					
Ctenopteris heterophylla (Labill.) M.D.Tindale							vr	
Polypodiaceae								
Microsorium diversifolium (Willd.) Copeland			o	f	o	o	r	r

Change in abundance of vascular plants on Mt. Wellington following fire

	Zones							
	1	2	3a	3b	4	5	6	7
Aspleniaceae								
Asplenium flabellifolium Cav.		o	o	o	o	o	r	r
A. bulbiferum Forst.f.			vr	r	vr	vr	f	
Aspidiaceae								
Rumohra adiantiformis (Forst.f.) Ching					r	vr	o	
Polystichum proliferum (R.Br.) C.Presl	r	o	f	f	f	o	c	r
Lastreopsis shepherdii (Kunze) M.D.Tindale							vr	
Blechnaceae								
Blechnum nudum (Labill.) Mett.			r	lc	lc		r	vr
B. aggregatum (Colenso) M.D.Tindale							f	
B. procerum [24] (Forst.f.)		r	c	c	c	f	c	r
B. fluviatile (R.Br.) E.J.Lowe			r	lc	o	vr	c	
B. penna-marina (Poir.) Kuhn	lc	lc	lc	l	l	vr	vr	vr
B. vulcanicum (Blume) Kuhn					r		r	
Lycopodiaceae								
Lycopodium scariosum Forst.f.	o							
L. varium R.Br.			r		r			
L. selago L.	vr							
L. fastigiatum R.Br.	o	o	o					
Psilotaceae								
Tmesipteris billardieri Endl.							vr	
GYMNOSPERMAE								
Podocarpaceae								
Phyllocladus asplenifolius [25] (Labill.) Hook.f.							vr	
Podocarpus lawrencii Hook.f.	r	r						

INTRODUCED SPECIES

(Alphabetical list)

Name	Zones in which species was observed
Agrostis tenuis/stolonifera	7,6,5,4,3b,3a,2,1
Aira caryophyllea	7,5,4,3b,3a
Aira praecox	5,3b
Anagallis arvensis	7,6,5,4,3b,3a
Anchusa sempervirens	4
Anthoxanthum odoratum	7,6,5,4,3b,3a,2
Arctotheca calendula	7
Arrhenatherum elatius	7,6,5,4,3b,2
Barbarea verna	7,6,4
Bellis perennis	7,6,5,4,2
Brassica spp.	7,4
Briza maxima	7
Briza minor	7,4
Bromus diandrus	7,6,4
Bromus mollis	7,6,4,3b
Calandrinia caulescens	4
Cardaria draba	7
Carduus tenuiflorus	7,4
Carex flacca	7,6,4,3b,3a
Centaurium erythraea	7,6,5,4,3b,3a
Centrantus ruber	7
Cerastium fontanum	7,6,5,4,3b,3a,2,1
Cerastium glomeratum	7,6,4
Chamaecytisus proliferus	7,4
Chrysantemoides monilifera	7
Chrysanthemum leucanthemum	7,5,4
Circium vulgare	7,4,3b,3a,2
Conium maculatum	7,6,4
Coronopus didymus	7,4
Cortaderia selloana	7
Crataegus monogyna	7,6,4
Crepis capillaris	5
Crepis setosa	7,6,5,4,3b,3a,2
Cynosurus cristatus	7,6,5,4,3b
Cynosurus echinatus	7,4
Dactylis glomerata	7,6,5,4,3b,3a,2
Digitalis purpurea	4,3b
Epilobium adenocaulon	6,4
Erica arborea	7,4
Erica lusitanica	7,4
Erodium cicutarium	7,4
Erodium moschatum	7
Euphorbia helioscopia	7
Euryops abrotanifolius	7,4
Europs abrotanifolius	7
Festuca arundinacea	3b
Festuca rubra	7,5,4,3b,3a,2
Foeniculum vulgare	7,5
Fumaria muralis	7
Galium aparine	7,4
Gastridium ventricosum	7
Genista monspessulana	7,6,4

Change in abundance of vascular plants on Mt. Wellington following fire

Gnaphalium candidissimum	7
Holcus lanatus	7,6,5,4,3b,3a,2
Hypericum androsaemum	7,4
Hypochaeris radicata	7,6,5,4,3b,3a,2,1
Ixia maculata	7
Juncus articulatus	7,6,5,4,3b,3a
Juncus bufonius	7,6,5,4,3b,3a
Lapsana communis	7,6
Leontodon leysseri	7
Lepidium campestre	7,4
Leycesteria formosa	6,4
Linum catharticum	7,6,5,4,3b,3a
Linum trigynum	7
Lithospermum arvense	7
Lolium perenne	7,6,5,4,3b,3a
Lotus tenuis	7,3b
Lunaria annua	4
Malva sylvestris	7
Matricaria matricarioides	7
Medicago arabica	7
Medicago lupulina	7,5,4
Melilotus indica	7,6
Mimulus moschatus	4
Monerma cylindrica	7
Myosotis sylvatica	6
Nasturtium officinale	7,6,4
Oxalis latifolia	7
Oxalis pes-caprae	7
Papaver dubium	7,4
Parentucellia latifolia	7
Parentucellia viscosa	7,6,5,4,3b,3a
Picris echioides	7
Picris hieracoides	7,4
Pinus radiata	7,6,4
Plantago coronopus	7,5,3a
Plantago lanceolata	7,6,5,4,3b,3a,2
Poa annua	7,6,5,4,3b,3a,2,1
Potentilla anglica	7,4
Poterium polygamum	7,4
Ranunculus repens	7,6,5,4,3b,3a
Raphanus raphanistrum	7,4
Rapistrum rugosum	7
Reseda luteola	7
Rosa rubiginosa	7,6,4,2
Rubus fruticosus	7,6,5,4
Rumex acetosella	7,5,4,3b,3a
Rumex crispus	7,6,4
Sagina apetala/procumbens	7,6,5,4,3b,3a,2,1
Salix alba x fragilis	6,4
Sambucus nigra	4
Sarothamnus scoparius	7,6,5,4,3b
Sedum acre	7,5
Senecio jacobea	3b
Senecio vulgaris	7,4
Sieglingia procumbens	4,3b
Silene gallica	7,4
Silybum marianum	7,4
Sisyrinchium iridifolium	7,4

Sonchus asper	7,6,4,3a
Sonchus oleraceus	7,6,4,3b
Spergula arvensis	4,3b
Spergularia rubra	4
Stachys arvensis	7
Stellaria media	7,4
Taraxacum officinale	7,6,5,4,3b,3a,2,1
Tragopogon porrifolius	7
Trifolium repens	7,4,2
Trifolium subterraneum	7
Ulex europaeus	7,6,5,4,3b,3a
Verbascum thapsus	4,3b,3a
Verbascum virgatum	7,4
Veronica persica	7
Vicia angustifolia	6
Vicia hirsuta	7,4,3b,3a
Vicia sativa	7,5,4
Vicia tetrasperma	7,4
Vinca major	7,4
Vulpia bromoides	7,6,4,3b,3a
Vulpia megalura	3b
Vulpia myuros	7,4

NOTES TO THE APPENDIX

(1) Incl. *A. australiensis* Mez.
(2) Incl. *D. racemosa* R.Br. and *D. penicillata* (Labill.) Beauv.
(3) An apparently undescribed species, differing from *D. microseta* in the characteristics of the leaves and the callus.
(4) Incl. *F. plebeia* R.Br.
(5) Incl. *P. labillardieri*, *P. gunnii*, *P. rodwayi*, *P. tenera* and the introduced species *P. pratensis* and *P. trivialis* (cf. Vickery, 1970).
(6) Syn. *G. psittacorum* Labill.
(7) All Mt. Wellington material is referable to var. *inops* Rodway.
(8) Syn. *Hypolaena lateriflora* (R.Br.) Benth.
(9) Discovered by the authors; the species is more robust than *J. sandwithii* and many specimens have only 3 stamens.
(10) The record includes *L. oldfieldii* Hook.f. in the upper zones and *L. flaccida* (Buch.) Edgar at lower elevations.
(11) The Tasmanian form is var. *obcordata* (Andr.) Benth.
(12) The record includes *P. gunnii* Benth. var. *baeckioides* Rodw., which is locally common on mudstone in zones 4 and 7.
(13) Incl. *A. echinata* Nees and *A. agnipila* Gandoger.
(14) Owing to the historical confusion concerning the names *E. gunnianum* and *E. billardierianum*, all species other than *E. rotundifolium* are included under this aggregate name. Also included are *E. cinereum* A. Rich. and some forms described in Curtis (1963) as *E. sarmentaceum* and *E. junceum*.
(15) Discovered on Mt. Wellington by the authors and is the first Australian record of this species which was hitherto known only from New Zealand and its surrounding islands (cf. Ratkowsky and Ratkowsky 1974).
(16) Syn. *O. alpina* (Hook.f.) W.M. Curtis.
(17) A species with leaf surfaces covered with white, cottony hairs. Possibly undescribed (W.M. Curtis, pers. comm.).
(18) Incl. the narrow-leafed form var. *oreophilum* W.M.Curtis, which is rare to occasional in zones 1 and 2.

(19) Most plants on Mt. Wellington are referable to the white-flowered form var. *ochroleuca* Rodw., but a few yellow-flowered plants were seen near the summit of Collins Bonnet.
(20) Syn. *S. centropappus* F.Muell.
(21) Syn. *E. squarrosa* Hook.f.
(22) Incl. *C. monilifera* L. Johnson.
(23) Syn. *G. dicarpa* R.Br. The Mt. Wellington form is referable to var. *alpina*.
(24) Incl. *B. minus* (R.Br.) Ettingsh., which most botanists consider to be a separate species. A range of intermediate forms occur on Mt. Wellington.
(25) The record refers to a large tree and a smaller tree at Fern Tree Bower, which have probably been planted. Natural stands occur near White Timber Mountain, just outside the western bounday of the survey area.

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BIOSTRATIGRAPHIC NOMENCLATURE FOR LATE PALAEOZOIC ROCKS IN TASMANIA

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(with five text-figures)

ABSTRACT

The Rekunian Series is proposed for part of the Late Palaeozoic (Stephanian-Kazanian Stages) of Tasmania. It is divided into four stages which are, in ascending order, the Hellyerian, the Tamarian, the Bernacchian and the Lymingtonian. The Epoch embraces the well-developed Tasmanian expression of the climax and retreat of the Gondwanan Late Palaeozoic glaciation, and witnesses the appearance and most prolonged development of the characteristic marine cold-water *Eurydesma* fauna anywhere in the world.

The Hellyerian Stage, which is represented wholly by thick tillite, glaciolacustrine rhythmite clay and other glacigene rocks, is sparsely fossiliferous, but the available evidence indicates that it pre-dates the appearance of both *Eurydesma* and *Glossopteris*. The Tamarian, Bernacchian and Lymingtonian Stages are mostly represented by shallow-water marine deposits in which glacially derived dropstones are frequently abundant, but subordinate glacigene strata, coal measures and other freshwater rocks are also present. The basis for stage recognition rests essentially with the nature of successive marine macro-invertebrate assemblages which constitute the *Eurydesma* fauna, and partly, but much less importantly, with broad lithological considerations. Subsidiary microfloral data are used to supplement and complement the macrofaunal information.

General lithological characters, the low to very low taxonomic diversity of faunas and floras, and palaeomagnetic data (Irving 1966) which indicate a position close to the south magnetic pole for Tasmania during Permo-Carboniferous times, all consistently point to cool or cold conditions throughout the Rekunian Epoch.

INTRODUCTION

The last two decades have witnessed profound advances in our understanding of the stratigraphy of Tasmanian (and other Australian) Late Palaeozoic (Permo-Carboniferous) rocks. In Tasmania, the initial impetus was provided by students of the Geology Department, University of Tasmania under the guidance of M.R. Banks (Banks, *in* Spry and Banks 1962). In more recent years the momentum has been maintained by the continuing detailed systematic 1:15 840 and 1:12 500 mapping programme of the Geological Survey of Tasmania. During this latter period, much additional information has also accrued from fully cored stratigraphic bore holes, and certain large scale civil engineering projects undertaken by the Hydro-Electric Commission and Associated Pulp and Paper Mills Pty. Ltd. As a result, detailed lithostratigraphic information became available for much of Tasmania, but in comparison, systematic biostratigraphic studies were somewhat neglected (Dickins 1968; Runnegar 1969*b*). However, since 1967, particular attention has been concentrated in this area so that detailed biostratigraphic information is now available for several definitive sections, and broadly consistent faunal distributions have been established in all sequences (Clarke and Banks 1975).

As work has progressed it has become increasingly apparent that most internationally accepted divisions of Late Palaeozoic time (based as they are on warm-water sequences characterised by an abundance of carbonates and evaporites associated with

Fig. 1. - Map showing principal localities referred to in the text.

diverse faunas which often contain reef-building corals, fusulinids and goniatites), cannot be applied with precision within the essentially cool- to cold-water Gondwanan realm where sequences display an unmistakeable 'glacial imprint'. This latter consideration is particularly true with respect to the Tasmanian sequence. As a result, informal local biostratigraphic zonal schemes have been proposed with an ever increasing frequency for the various Australian sequences (Hill 1952; Dickins 1963; Dickins *et al.* 1964; Runnegar 1967*a*; 1969*b*; Dear 1972*a*; Clarke and Banks 1975). Waterhouse (1967, 1969) has proposed formal chronostratigraphic nomenclature for the New Zealand Permian and most recently, Runnegar and McClung (1975), have outlined a broad synthesis for all eastern Australian sequences. In our view, such syntheses are premature. Whereas we concede a limited consensus concerning broad biostratigraphic correlations throughout eastern Australia and New Zealand, it is salutary to compare the major discrepancies which are apparent between correlations of the various eastern Australian and New Zealand sequences as proposed by Waterhouse (1969, 1970, 1971), Runnegar and McClung (1975), Clarke (1974), Dear (1972*a*), and Clarke and Banks (1975).

In view of these considerations, and now that the systematic description of Tasmanian faunas is about to commence, we consider that such description be best made within the framework of formal local biostratigraphic nomenclature. The various biostratigraphic units herein proposed are selected in accordance with the Australian Code of Stratigraphic Nomenclature (4th Edition, 1964 as revised 1973), Articles 39, 40 and 42, and the names have been registered with the Central Register of Australian Stratigraphic Names, maintained at the Bureau of Mineral Resources, Canberra. It is our belief that the description of the Tasmanian faunas will proceed most expeditiously, and with least risk of misunderstanding, within this framework. It should be noted that the lithostratigraphic and biostratigraphic criteria used throughout this paper are essentially those which are more fully stated in Claike and Banks (1975), but minor additions and amendments in keeping with more recent work are also included. Rather paradoxically the impending description of Tasmanian marine invertebrate faunas will require relatively few additional taxa. For example, one of the most characteristic species is the long-established *Trigonotreta stokesi* Koenig, 1825. This species was the first described Australian fossil taxon, and contrary to the statements of Armstrong (1968), is both morphologically

and stratigraphically quite distinct from *Grantonia hobartensis* Brown, 1953. Other examples of long-established and valid Tasmanian taxa include *Fusispirifer avicula*, *Sulciplica tasmaniensis*, *Taeniothaerus subquadratus*, *Terrakea brachythaera* [= *T. solida Etheridge* and Dun] *Deltopecten limaeformis*, *D. squamuliferus*, *Etheripecten fittoni*, *Merismopteria macroptera* and *Stutchburia compressa* (Morris *in* Strzelecki 1845); *Wyndhamia jukesi* (Etheridge, 1880); *Eurydesma hobartensis* and *Megadesmus grandis* [as *Notomya trigonalis*] (Johnston 1887, 1888); and *Keeneia twelvetreesi* (Dun, 1912). Most of the remaining forms are specifically comparable with material described more recently from elsewhere in Australia and New Zealand (Booker 1929; Hill 1950; Crockford 1951; Maxwell 1954; Dickins 1956, 1957, 1963; Fletcher 1958; Campbell 1959, 1960, 1961, 1965; Runnegar 1965, 1967, 1969a, 1970, 1972; Wass 1968, 1969; Thomas 1971; Waterhouse 1964; 1968; Dear 1972*b*; Armstrong 1970; McClung and Armstrong 1975). All marine macro-invertebrate taxa recorded to date from the Rekunian Series are listed in Appendix 1.

REKUNIAN SERIES

Name:

The Rekunian Series is named after Rekuna, south-eastern Tasmania. Rekuna was the Aboriginal name for the now extinct Tasmanian emu, a species which inhabited much of the terrain occupied by the outcrop of the Rekunian Series.

Relation to other sequences

The strata which comprise the Rekunian series are almost always sub-horizontal. They rest with profound landscape unconformity on a folded basement composed of Precambrian and early Palaeozoic rocks intruded by Late Devonian to Early Carboniferous granites (McDougall and Leggo 1965). Basement surfaces are often scoured, plucked and striated. The Rekunian Series is followed transitionally or paraconformably by subhorizontal, wholly non-marine sequences which comprise the Upper Parmeener Super-Group (Forsyth *et al.* 1974) of Permo-Triassic age.

Subdivision

Four stages are recognised. They are, in ascending order, the Hellyerian, Tamarian, Bernacchian and Lymingtonian (fig. 2).

HELLYERIAN STAGE

Name

The stage is named after the Hellyer Gorge, north-western Tasmania.

Reference section

The section is the lower and middle parts of the Wynyard Tillite as exposed in the Hellyer Gorge. The sequence consists of thick tillite, with subordinate glaciolacustrine rhythmite clay, and minor turbidite sandstone layers.

Biota

Fossils, which are rare throughout the Hellyerian Stage, include anostracans, *Gyrochorte*, a megasecopteran insect, *Tasmanadia twelvetreesi* Chapman (interpreted as the trails of euthycarcinoid crustaceans by Riek (1973), *Botrychiopsis* [*Rhacopteris*] *plantiana* (Carruthers), and a Stage 1 *Potonieisporites* Microflora (*sensu* Evans 1969; Helby 1969; Kemp 1975). A spinose acritarch *Veryhachium* occurs sparingly at Pine Point, Wynyard and at Strahan (Kemp pers. comm.), and lends support to the hypothesis of wet-base glaciers discharging their debris at or below sea-level as a mechanism for depositing large thicknesses of tillite (Carey and Ahmad 1961).

Comments

In view of the paucity of biota, the Hellyerian Stage is provisionally conceived as the total range of the Stage 1 *Potonieisporites* Microflora in the Hellyer Gorge

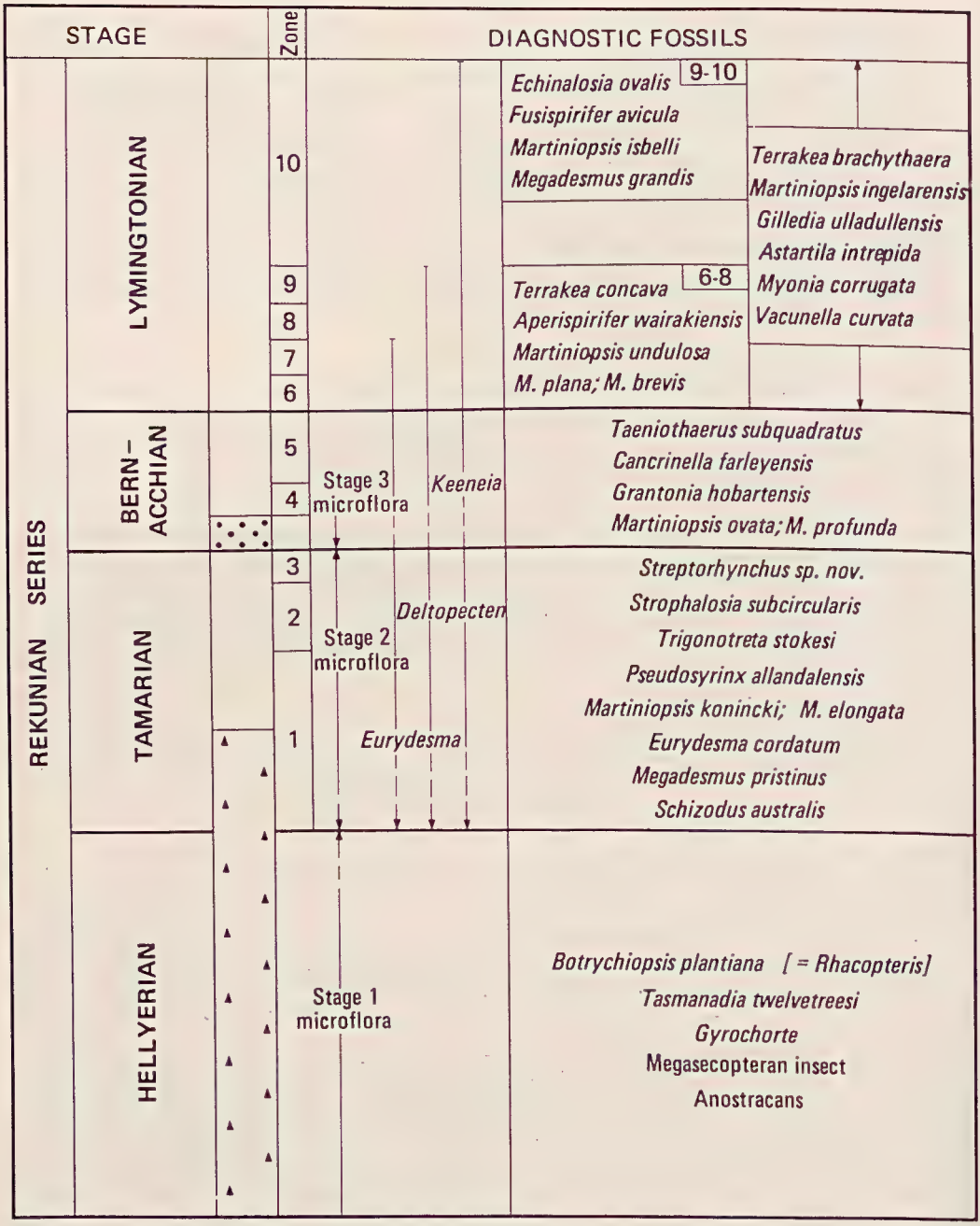

Fig. 2. - Stage subdivision of the Rekunian Series. In the generalised stratigraphic column the triangles represent tillite and other glacigene rocks, the dots represent coal measures and other freshwater rocks, and marine sequences with dropstones are left blank.

section. Although the evidence is not conclusive, the Hellyerian Stage appears to represent an interval of time prior to the appearance of the *Eurydesma-Glossopteris* association (see later).

Correlation and age

The Hellyerian Stage is the Tasmanian equivalent of the Stage 1 *Potonieisporites* Microflora elsewhere in eastern Australia. A Late Carboniferous (late Stephanian) age is assigned to the Stage 1 *Potonieisporites* Microflora by Evans (1969) and Helby (1969).

Distribution

Hellyerian biota are known only from the Wynyard Tillite in the Hellyer Gorge section, from near the base of the same formation at Pine Point near Wynyard, and in basal sequences of tillite and glaciolacustrine clay near Strahan, West Tasmania. However, it seems most probable that the lower parts of thick glacigene sequences in the Woodbridge-Cygnet area, the Maydena area, and the Lake River-Poatina area are also of Hellyerian age. All palynological residues so far obtained from the Woodbridge-Cygnet area have been much carbonised (Helby; Kemp pers. comm.), and the other sequences have yet to be sampled systematically.

TAMARIAN STAGE

Name

The name is derived from the Tamar River, northern Tasmania.

Reference section

The section is the Masseys Creek Group (Gee and Legge 1974) exposed in Andersons Creek and West Arm, near Beaconsfield, Tamar Valley. The sequence is wholly marine and consists of ill-sorted mudstone, siltstone and sandstone with abundant glacially derived dropstones, together with minor tillite, limestone and glauconitic sandstone. The lowest parts of the Andersons Creek and West Arm section are rather indifferently exposed, but closely similar successions through this interval have been recorded in two fully cored bore holes (Clarke, *in* Gee and Legge 1974). Whereas the section in Andersons Creek and West Arm cannot be regarded as complete and definitive in itself, all three Tamarian assemblage faunizones are present in undoubted superposition (fig. 3). These zones are, in ascending order:- the zone of *Streptorhynchus* sp. nov. with *Megadesmus pristinus*, the zone of *Eurydesma cordatum*, and the zone of *Sulciplica* sp. nov. The base of the Tamarian Stage occurs in the Hellyer Gorge section. It may be necessary to select individual Tamarian faunizone stratotypes away from the Andersons Creek and West Arm section. Particularly well-exposed, continuously fossiliferous coastal sections at Wheatleys Bay and Drip Beach, Huon River area, south-east Tasmania, and near Darlington, Maria Island, are all worthy of consideration.

Biota

Fossils are abundant throughout the Tamarian Stage which can be defined as the total range of *(inter alia) Trigonotreta stokesi* Koenig and the Stage 2 Microflora. Other diagnostic forms include *Streptorhynchus* sp. nov., *Strophalosia subcircularis* Clarke, *Martiniopsis koninckí* Etheridge, *M. elongata* McClung and Armstrong, *Pseudosyrinx allandalensis* Armstrong, *Eurydesma cordatum* Morris, *Deltopecten waterfordi* Dickins, *Megadesmus pristinus* Runnegar, *Phestia darwini* (de Koninck), *Pyramus laevis* (J. Sowerby) and *Schizodus australis* (Runnegar). A profusion of large, coarsely-ribbed *Deltopecten*, *Eurydesma* spp. and large *Keeneia* spp. is characteristic. Other forms include *Sulciplica* sp. nov., *S. stutchburii* Auctt, *Etheripecten* sp., *Merismopteria* sp., *Myonia elongata* Dana, *M. morrisi* (Etheridge), *Stutchburia* spp., *Peruvispira* sp, *Rhabdocantha* sp., *Calceolispongia*, *Camptocrinus*, *Jimbacrinus*, rare conulariids, and a variety of bryozoans, but most of these persist beyond the Tamarian Stage. By virtue of the continuously marine facies, the *Glossopteris-Gangamopteris* association is

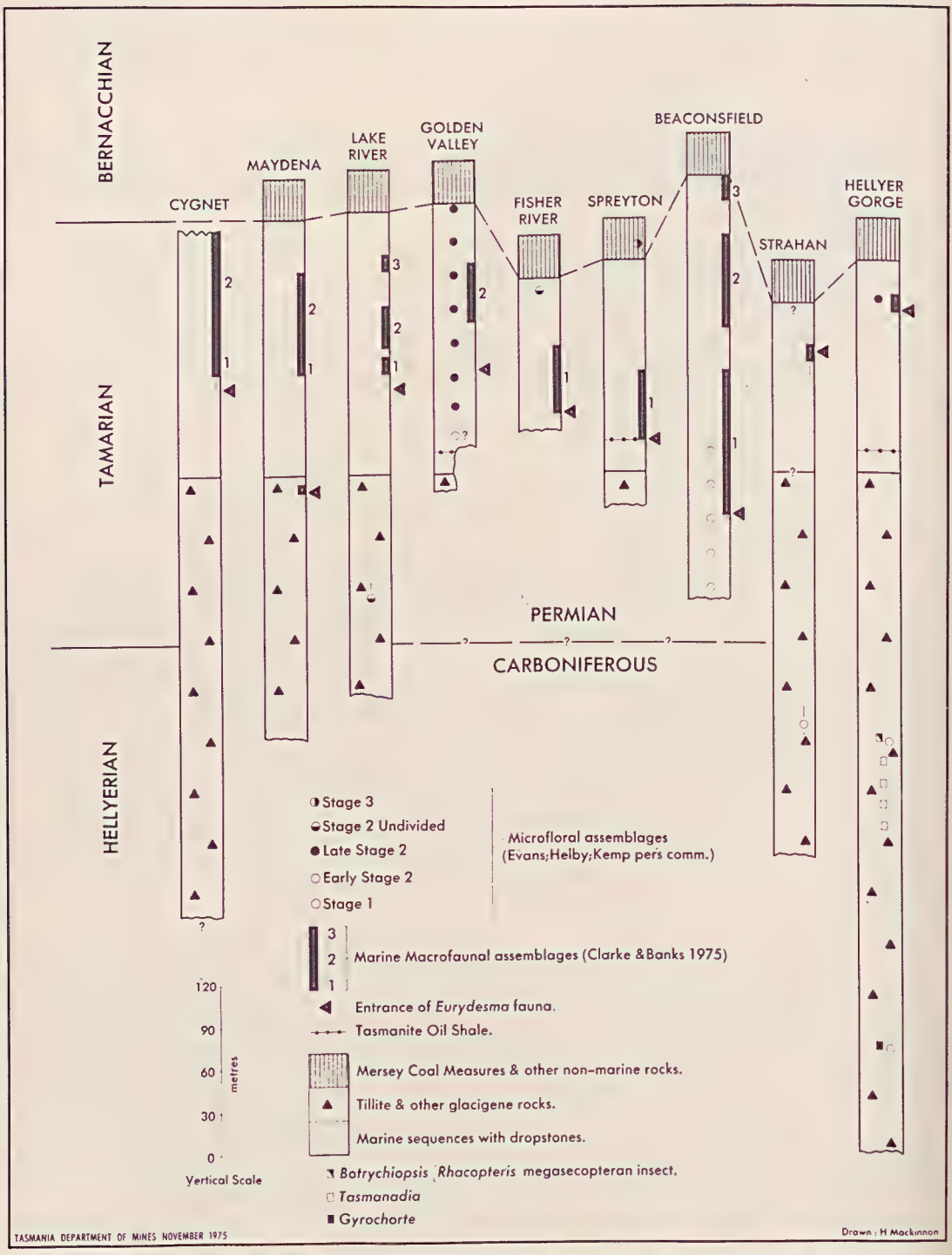

Fig. 3. - Comparative stratigraphic data for the lower parts of the Rekunian Series.

poorly represented below the succeeding Bernacchian State, but rare specimens of *Gangamopteris* are known from early Tamarian horizons in several sequences (Woody Island Formation, south-eastern Tasmania, and Quamby Formation, Great Western Tiers).

Although the evidence is not conclusive, there are compelling grounds to suggest that the Stage 2 Microflora is the microfloral expression of the appearance of the *Glossopteris-Gangamopteris* association. If this is so, then both the *Glossopteris* and *Eurydesma* associations entered the Tasmanian sequence virtually contemporaneously (fig. 3).

Correlation and age

The Tamarian Stage is the Tasmanian equivalent of the Sydney Basin Allandale Fauna (Runnegar 1969*b et seq.*) and its constituent zones (Runnegar and McClung 1975). Runnegar (1969*b*) discussed the correlation of the eastern and western Australian sequences, and concluded from the Western Australian ammonoid evidence that the Allandale Fauna is of late Asselian or early Sakmarian age. The Tamarian Stage is older than the New Zealand Telfordian Stage which is assigned to the Sakmarian (Waterhouse, 1967 *et seq.*).

Distribution

Tamarian biota occur widely throughout Tasmania in a considerable variety of lithofacies. The predominant rock types include ill-sorted mudstone, siltstone and sandstone. Subordinate rock types include Tasmanite Oil Shale, glendonitic siltstone, coarse arkosic sandstone, limestone and coquinite. Glacially derived dropstones are always much in evidence.

BERNACCHIAN STAGE

Name

The name is derived from Bernacchi's Creek, near Darlington, Maria Island, East Tasmania.

Reference section

The section includes the 'Freshwater Beds'. 'Productus Zone' and 'Crinoidal Zone' (Banks 1958) as exposed in cliff and quarry sections near Darlington, Maria Island. The lowest part of the sequence is non-marine carbonaceous shale with abundant plant fossils, but the upper parts consist of compact calcareous siltstone and coarse crinoidal limestone with rich shelly marine faunas. Dropstones characterise the marine strata.

Biota

The lowest beds, which are everywhere non-marine, yield abundant *Glossopteris*, *Gangamopteris* and *Noeggerathiopsis*, and at Sassafras near Latrobe, the Mersey Coal Measures (in their type area) yield microfloras referable to Stage 3 (Kemp pers. comm.). Above this, diagnostic forms include *Anidanthus springsurensis* (Booker), *Cancrinella farleyensis* (Etheridge and Dun), *Taeniothaerus subquadratus* (Morris), *Terrakea pollex* Hill, *Grantonia hobartensis* Brown, *Martiniopsis ovata* (Campbell), *M. profunda* (Campbell), *M. profunda* (Campbell), *M. valida* (Campbell), *Pseudosyrinx procera* (Armstrong), and *Thaumatoblastus longiramus* Wanner. Other characteristic forms include *Deltopecten* spp., *Eurydesma* spp., *Keeneia* spp. and *Calceolispongia*, which are all survivors from the Tamarian Stage below; and *Cladochonus*, *Thamnopora*, *Euryphyllum*, *Schuchertella*, *Echinalosia preovalis* (Maxwell), *Wyndhamia jukesi* (Etheridge) - *dalwoodensis* Booker, *Cleiothyridina*, *Spirigerella*, *Grantonia cracovensis* Wass, *Sulciplica tasmaniensis* (Morris), *Punctospirifer*, *Atomodesma (Aphanaia)*, *Conocardium*, *Megadesmus nobilissimus* (de Koninck), *Paraconularia derwentensis* (Johnston) and rare trilobites (Wass and Banks 1971), all of which survive into the Lymingtonian Stage above. Two zones can be recognised within the marine Bernacchian. They are a lower zone with

Echinalosia preovalis pristina, and an upper zone with *Taeniothaerus subquadratus*. Both zones yield abundant *Cancrinella farleyensis*.

Comments

Unfortunately marine sequences spanning the Tamarian-Bernacchian boundary are unknown in Tasmania. The base of the Bernacchian Stage is placed at the base of the freshwater sequence (Mersey Coal Measures and correlates) for three reasons:

(1) The base of the freshwater sequence is readily mappable throughout most of Tasmania.
(2) The freshwater beds yield microfloras referable to Stage 3.
(3) By biostratigraphic correlation with the Sydney Basin, the Tasmanian freshwater interval would (if marine) be expected to yield a *branxtonensis* zone assemblage (*sensu* Runnegar and McClung, 1975). The affinities of *branxtonensis* zone (lower Farley) assemblages are clearly with Bernacchian faunas rather than with Tamarian faunas.

The Bernacchian Stage as defined is thus typified firstly by limited developments of coal measures and other non-marine rocks, followed by the most pronounced development of carbonate sedimentation anywhere in the Tasmanian sequence. These factors together with a small but definite increase in the taxonomic diversity of the marine macrofaunas (fig. 4), have been used to support a significant amelioration in climatic conditions (Waterhouse 1969, 1970, 1971). However, the evidence is rather equivocal since dropstones are always present in marine Bernacchian sequences, the more so in wholly clastic detrital (and non-carbonate) sequences in the Maydena (Jago, 1972) and Frankford areas (Gulline, in press). Furthermore, the overlying Lymingtonian faunas display a slightly greater taxonomic diversity, yet dropstones remain abundant, coal measures are absent, and carbonates are rare, thin and discontinuous. The most recent data presented by Waterhouse and Bonham-Carter (1975) now show substantial agreement as to the cool-water aspect of Tasmanian faunas.

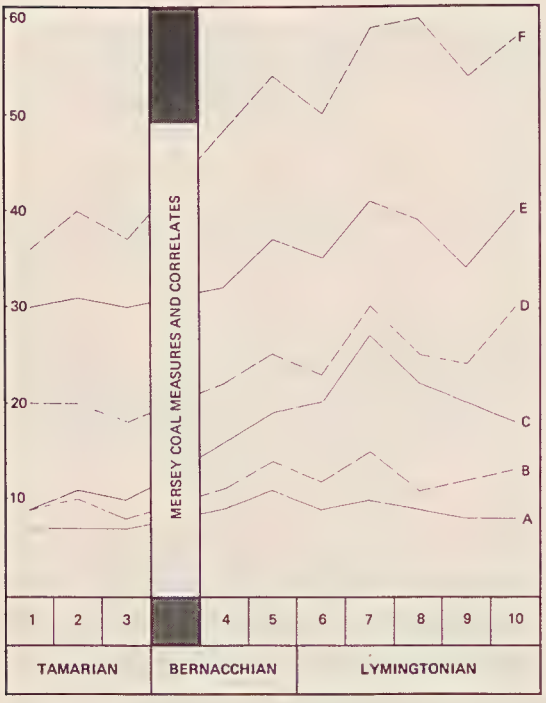

Fig. 4. - Frequency distributions of Rekunian marine macro-invertebrates. A. brachiopod families, B. brachiopod genera, C. brachiopod species, D. brachiopod and pelecypod genera, E. all genera, F. all species.

Correlation and age

The Bernacchian Stage is the Tasmanian equivalent of Fauna I and Fauna II in the Queensland Bowen Basin (Dickins *et al.*, 1964) and Fauna II in the Sydney Basin (Runnegar, 1969) and their constituent zones (Runnegar and McClung, 1975). Runnegar (1969) discusses the correlation of the eastern and western Australian sequences and concluded

from the ammonoid evidence that Fauna II ranges in age from late Sakmarian (Sterlitamakian) to early Artinskian (Aktastinian). The New Zealand Telfordian and Mangapirian Stages (Waterhouse, 1967) appear to be approximately equivalent with the Bernacchian Stage, but the basis for comparison is somewhat imprecise. The Mangapirian Stage may range beyond the limits of the Bernacchian Stage (Clarke and Banks, 1975).

Distribution

Early Bernacchian floras and microfloras are widely distributed throughout Tasmania (Mersey Coal Measures; Liffey Sandstone; Faulkner Group and correlates, see (fig. 5). Late marine Bernacchian faunas are less widely distributed but they are well-developed at Granton, Maydena, Frankford, Maria Island and much of North-east Tasmania. Southwards from Granton, Bernacchian rocks thin rapidly and disappear south of Snug (Farmer, in press) so that throughout the Cygnet area Lymingtonian sequences rest directly on incomplete Tamarian sequences.

LYMINGTONIAN STAGE

Name

The name is derived from Lymington, Huon River area, South-east Tasmania.

Reference section

The section includes unnamed formations of siltstone and sandstone (Farmer, in press), and Ferntree Group as exposed at Deep Bay, Cygnet area, Huon River (Clarke and Banks 1975 ; Farmer in press). The sequence consists predominantly of compact, ill-sorted siltstone and sandstone, with subordinate coarse-grained, cross-bedded sandstone (Risdon Sandstone) and other thin, coarse-grained, gritty arkosic layers. Dropstones occur more or less abundantly throughout. Marine fossils are very common particularly in the lower parts of the section, but decrease in abundance towards the top where worm burrows and other biogenic structures predominate.

The Deep Bay section realises most of the attributes of the ideal stratigraphic section. It is continuously exposed and unfaulted, continuously fossiliferous, the fossils are well-preserved, and for most part, there are no abrupt changes in lithology. Unfortunately, the base of the section is not exposed. However, diamond drilling and other coastal sections in the Cygnet area indicate that Bernacchian strata are wholly absent so that Lymingtonian rocks rest on an incomplete Tamarian sequence. This difficulty can be resolved by virtue of the fact that the top of the Maria Island Bernacchian section can serve as the base of the Lymingtonian Stage. Biostratigraphic details indicate that no significant or substantial portion of the Deep Bay section is missing.

Biota

Fossils are abundant at many levels throughout the Lymingtonian Stage. Their abundance decreases upwards but definitive and well-preserved faunas are known from many localities only a few metres below the top of the Stage (Clarke 1973). One of these at Point Puer, is the locality from which *Terrakea brachythaera* was originally described (Morris, *in* Strzelecki 1845). Diagnostic forms which range throughout include *Terrakea brachythaera* (Morris), *Martiniopsis ingelarensis* (Campbell), *Fletcherithyris parkesi* (Campbell), *Gilledia ulladullensis* (Campbell), *Astartila intrepida* (Dana), *Myonia corrugata* (Fletcher) and *Vacunella curvata* (Morris). Other characteristic but shorter-ranging species include *Echinalosia ovalis* (Maxwell), *Terrakea concava* (Waterhouse), *Aperispirifer wairakiensis* (Waterhouse, *Fusispirifer avicula* (Morris), an important evolutionary lineage of *Martiniopsis* through *M. plana* (Campbell) *M. brevis* McClung and Armstrong - *M. undulosa* (Campbell), *M. isbelli* (Campbell), *M. angulata* (Campbell), *M. globosa* (Campbell), *M. streleckii* (de Koninck), *Sulciplica transversa* Waterhouse, *Plekonella acuta* (Campbell), *Astartella*, *Etheripecten leniusculus*, *Warthia micromphala* (Morris) and *Walnichollsia subcancellata* (Morris). It is the restricted vertical distributions of these more short-ranged species, together with

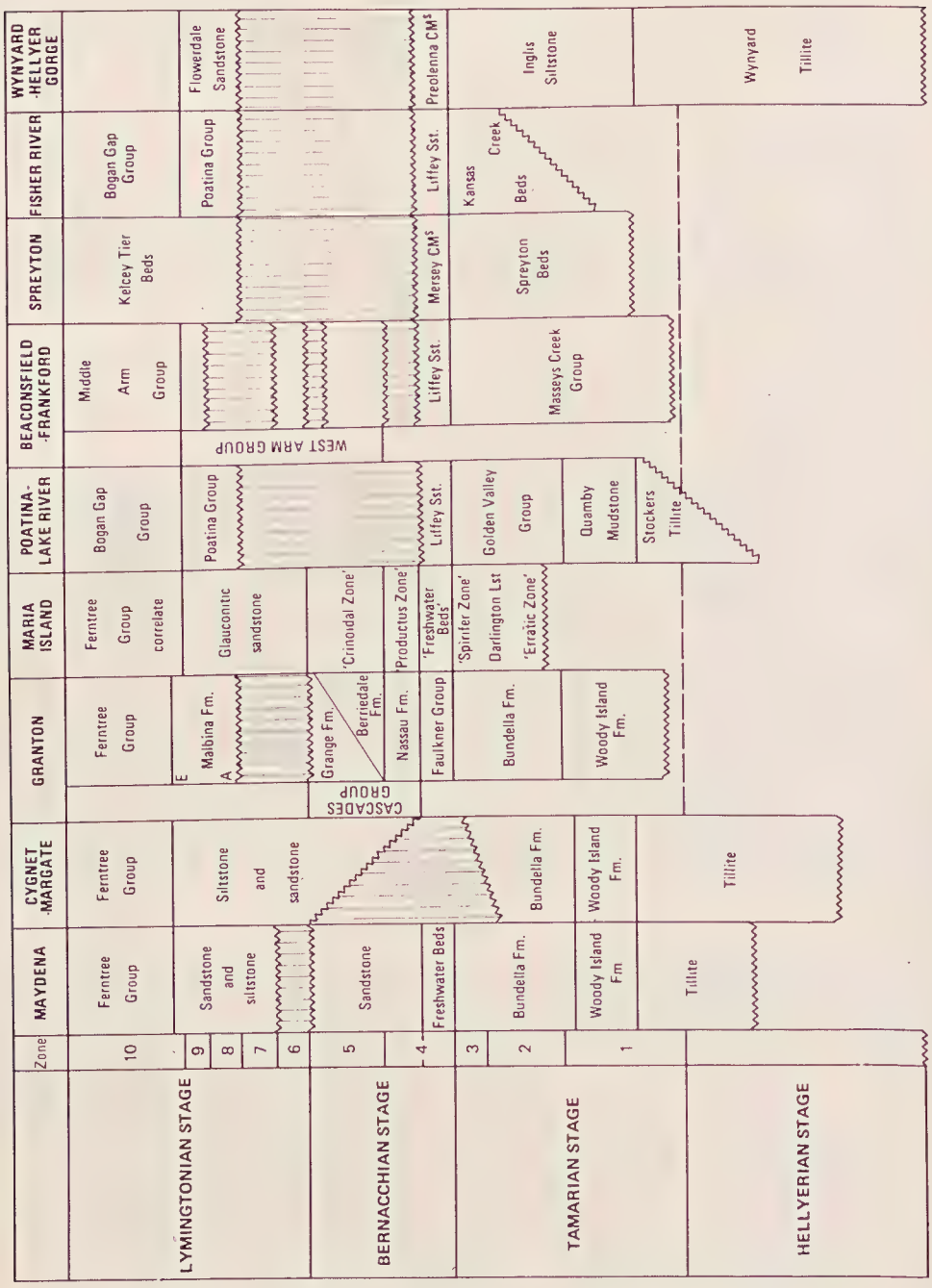

Fig. 5. - Intercorrelation of the Rekunian Series in Tasmania.

the disappearance of certain long-ranged Tamarian and Bernacchian species and genera such as *Deltopecten, Eurydesma, Echinalosia preovalis, Wyndhamia dalwoodensis, Cleiothyridina, Punctospirifer, Grantonia cracovensis,* and *Sulciplica tasmaniensis,* which allow the recognition of the five zonal assemblages (Clarke and Banks 1975) which comprise the Lymingtonian Stage. These are, in ascending order:- the zone of *Martiniopsis plana* (with *Eurydesma* and *Deltopecten*), the zone of *Martiniopsis brevis* (with *Eurydesma, Deltopecten* and *Terrakea concava*), the zone of *Martiniopsis undulosa* (with *Deltopecten* and *Terrakea concava*), the zone of *Martiniopsis isbelli* (with *Deltopecten*), and the zone of *Echinalosia ovalis* and *Megadesmus grandis.* Poorly-preserved plants occur sporadically throughout the Stage. Abundant and well-preserved *Glossopteris, Gangamopteris* and other plants occur in the Cygnet Coal Measures, Jackey Formation and correlates, but these are beyond the limits of the Rekunian Series (Forsyth *et al.* 1974).

Correlation and age

The Lymingtonian Stage is the Tasmanian equivalent of the New Zealand Braxtonian Stage (Waterhouse 1967); of Fauna III and Fauna IV in the Queensland Bowen Basin (Dickins *et al.* 1964); and of the Ulladulla Fauna and Fauna IV in the Sydney Basin (Runnegar 1969) and their constituent zones (Runnegar and McClung 1975). The early Lymingtonian is probably of late Artinskian (Baigendzhinian) age since ammonoids of this age occur in the lower parts of Fauna III in Queensland (Armstrong *et al.* 1967). The late Lymingtonian may be as young as Kazanian since a Kazanian age is generally accepted for Fauna IV in eastern Australia (Dickins 1968, 1970; Runnegar 1969*b*), and a Kazanian age is advocated for the Late Braxtonian (Flettian) Stage in New Zealand (Waterhouse 1969 *et seq.*).

Distribution

Lymingtonian biota are widespread throughout Tasmania. Characteristically they occur in more or less strongly bioturbated and ill-sorted siltstone and sandstone. Lesser developments of limestone, calcareous siltstone, bryozoal shale, coarse arkosic sandstone and conglomerate, glauconitic sandstone and quartz conglomerate also occur. Glacially derived dropstones occur throughout.

SUMMARY AND CONCLUSIONS

Four stages are erected within the predominantly marine Tasmanian Late Palaeozoic (Permo-Carboniferous) Rekunian Series. The basal Hellyerian Stage is represented entirely by thick sequences of glacigene rocks which are poorly fossiliferous. However, the biota presently known indicate that, in Tasmania, the main Gondwanan glacial episode reached its climax no later than Stephanian, and almost certainly pre-dated the appearance of the *Eurydesma* and *Glossopteris* associations. The Tamarian, Bernacchian and Lymingtonian Stages are represented predominantly by marine sequences with abundant glacially derived dropstones. The Tasmanian lithostratigraphic and biostratigraphic details indicate a consistently cold- to cool-water environment with perhaps a slight and gradual upward amelioration in conditions until the end of marine sedimentation.

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Appendix

Rekunian marine macro-invertebrates and their zonal distributions. The zones are numbered in upward sequence from 1-10. First and last appearances are given. Certain less abundant species have not necessarily been recorded from each individual zone throughout their total ranges. The common species are indicated by asterisks.

Brachiopods

Orbiculoidea sp. 6
Schuchertella sp. 1-8.
**Streptorhynchus* sp. nov. 1
Costalosia apicallosa Clarke 2
Echinalosia maxwelli (Waterhouse) 7-8
**Echinalosia ovalis* (Maxwell) 10
Echinalosia preovalis (Maxwell) 4-8
**Echinalosia preovalis pristina* (Maxwell) 4
**Strophalosia subcircularis* Clarke and variants 2-3
**Strophalosia* sp. nov. 1
Wyndhamia irregularis Clarke 2
**Wyndhamia jukesi* (Etheridge) 4-5
**Wyndhamia dalwoodensis* Booker 5-9
**Taeniothaerus subquadratus* (Morris) 5
Anidanthus springsurensis (Booker) 5
Anidanthus sp. 7-8
**Cancrinella farleyensis* (Etheridge and Dun) 4-5
**Terrakea brachythaera* (Morris) 6-10
**Terrakea concava* Waterhouse 7-8
Terrakea dickinsi Dear 5-6
Terrakea pollex Hill 5
Cleiothyridina sp. 5-7
Spirigerella sp. 5-8
**Aperispirifer wairakiensis* (Waterhouse) 6-8
**Aperispirifer lethamensis* Waterhouse 7-10
**Fusispirifer avicula* (Morris) 9-10
Fusispirifer sp. nov. 7-9
Grantonia cracovensis Wass 5-8
**Grantonia hobartensis* Brown 4-5
Sulciplica phalaena (Dana) 7-10
**Sulciplica stutchburii* Auctt. 3-7
**Sulciplica transversa* Waterhouse 7-10
**Sulciplica* sp. nov. 3
**Trigonotreta stokesi* Koenig 1-3
**Martiniopsis angulata* (Campbell) 6-10
**Martiniopsis brevis* McClung and Armstrong 7
**Martiniopsis elongata* McClung and Armstrong 1
Martiniopsis globosa (Campbell) 10
Martiniopsis ingelarensis (Campbell) 6-10
**Martiniopsis isbelli* (Campbell) 9
**Martiniopsis koninckii* Etheridge 2-3
**Martiniopsis magna* (Campbell) 6-10
**Martiniopsis ovata* (Campbell) 4-5
**Martiniopsis plana* (Campbell) 6
**Martiniopsis plica* (Campbell) 6-7
**Martiniopsis profunda* (Campbell) 4-5
**Martiniopsis strzeleckii* de Knoinck 6-9
**Martiniopsis undulosa* (Campbell) 8
Martiniopsis valida (Campbell) 5

Martiniopsis sp. nov. A (coarsely plicate) 7-8
**Martiniopsis* sp. nov. B (giganteid form) 10
Notospirifer extensus Campbell 6
Notospirifer minutus Campbell 9-10
'Spirifer' duodecemcostatus M'Coy 9-10
**Notospiriferid* gen.nov. 10
Cyrtella nagmargensis australis Thomas 1
**Pseudosyrinx allandalensis* Armstrong 1-3
Pseudosyrinx procera (Armstrong) 4-5
'Pseudosyrinx' ulladullensis (Armstrong) 6-8
'Pseudosyrinx' spp. 9-10
Punctospirifer australis (Etheridge) 4-7
Punctospirifer etheridgei Armstrong 6-9
Plekonella acuta Campbell 10
Rhynchonellid indet. 5
**Fletcherithyris amygdala* (Dana) 6-10
**Fletcherithyris farleyensis* Campbell 4-5
**Fletcherithyris parkesi* Campbell 6-10
Fletcherithyris reidi Campbell 5-8
**Fletcherithyris* spp. 1-10
Gilledia homevalensis Campbell 4-5
**Gilledia oakiensis* Campbell 6-8
Gilledia ulladullensis Campbell 6-10
**Gilledia* spp. 1-10

Pelecypods

Astartella sp. 7
**Astartila intrepida* (Dana) 6-10
**Atomodesma (Aphanaia)* sp. 4-10
**Deltopecten illawarensis* (Morris) 1-9
**Deltopecten limaeformis* (Morris) 4-9
Deltopecten squam-liferus (Morris) 5-8
Deltopecten waterfordi Dickins 1-3
Etheripecten farleyensis (Etheridge and Dun) 5-8
**Etheripecten fittoni* (Morris) 5-10
**Etheripecten leniusculus* (Dana) 9-10
**Etheripecten tenuicollis* (Dana) 1-3
**Etheripecten* spp. 1-10
**Eurydesma cordatum* Morris 2
**Eurydesma hobartensis* (Johnston) 1-7
Eurydesma playfordi Dickins 2
**Eurydesma* spp. 1-7
**Megadesmus grandis* (Dana) 10
**Megadesmus gryphoides* (de Koninck) 6-10
**Megadesmus nobilissimus* (de Koninck) 4-8
Megadesmus pristinus Runnegar 1
Megadesmus sp. 2-3
Merismopteria carrandibbiensis (Dickins) 1-8
**Merismopteria macroptera* (Morris) 10
**Merismopteria* sp. 1-10
**Myonia carinata* (Morris) 6-10
**Myonia corrugata* Fletcher 6-10
Myonia elongata Dana 3
**Myonia morrisi* (Etheridge) 1-3
**Myonia triangulata* (Waterhouse) 10
Nuculopsis (Nuculopsis) sp. 10
Oriocrassatella sp. 10

Phestia darwini (de Koninck) 1
Phestia sp. 10
Pleurikodonta elegans Runnegar 10
Promytilus cancellatus Maxwell 1
**Pyramus laevis* (J. Sowerby) 1-3
Pyramus myiformis (Dana) 9-10
**Schizodus australis* (Runnegar) 1-3
Schizodus spp. 4-10
Streblochondria sp. 4-8
**Streblopteria* spp. 2-10
**Stutchburia costata* (Morris) 8-10
**Stutchburia compressa* (Morris) 6-10
Stutchburia cuneata (Dana) 10
'Stutchburia' edelfelti (Etheridge) 10
**Stutchburia* spp. 1-10
**Vacunella curvata* (Morris) 6-10
Volsellina mytiliformis (Etheridge) 8
Pelecypod gen. nov. 7-8

Gastropods

**Keeneia ocula* (J. Sowerby) - *platyschismoides* Etheridge 1-10
Keeneia trochiforme Fletcher 5-8
**Keeneia twelvetreesi* Dun 1-3
Mourlonopsis strzeleckiana Morris 10
Paromphalus ammonitiformis (Etheridge) 1-3
**Peruvispira* spp. 1-10
**Ptychomphalina* spp. 1-10
Rhabdocantha sp. 3
Strotosoma sp. 7-8
**Walnichollsia subcancellata* (Morris) 7-10
**Warthia micromphala* (Morris) 9-10

Rostroconchs

Conocardium sp. 4-10

Hyolithids

Hyolithes sp. 8-10.

Cephalopods

Michelinoceratid nautiloids 5-8

Coelenterates

Notoconularia spp. 2-10
**Paraconularia derwentensis* (Johnston) 5-8
Paraconcularia sp. 2-8
Cladochonus nicholsoni (Etheridge) 5-8
Thamnopora wilkinsoni Etheridge 5-8
Euryphyllum spp. 4-10
?Plerophyllum sp. 5

Echinoderms

Thaumatoblastus longiramus Wanner 5

Blastoid indet. 8
Calceolispongia sp. 1-5
Camptocrinus sp.. 3-5
Jimbacrinus sp. 1-2
Phialocrinus sp. 10

Trilobites

Doublatia sp. 4-8

Bryozoans

Fenestella canthariformis Crockford 6-10
**Fenestella dispersa* (Crockford) 1-10
**Fenestella fossula* Lonsdale 1-10
Fenestella granulifera (Crockford) 4-8
Polypora magnafenestrata Crockford 5
Polypora woodsi (Etheridge Jr) 4-5
Protoretepora ampla Lonsdale 1-5
Stenodiscus sp. 5
**Stenopora crinita* Lonsdale 4-10
**Stenopora ovata* Lonsdale 1-10
**Stenopora tasmaniensis* Lonsdale 1-3
**Streblocascopora marmionensis* (Bretnall) 1-5

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THE SIGNIFICANCE AND PROVENANCE OF STROMATOLITIC CLASTS IN A PROBABLE LATE PRECAMBRIAN DIAMICTITE IN NORTHWESTERN TASMANIA

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(with three text-figures and six plates)

ABSTRACT

Two types of stromatolitic dolomite boulders occur in a diamictite of possibly late Precambrian age in northwestern Tasmania; they are the oldest Tasmanian fossils so far recorded. The first type comprises dark grey dolomites containing the stromatolite *Baicalia* cf. *B. burra*, generally well preserved. The remainder are pale grey rather recrystallised dolomites containing stratiform and columnar-layered stromatolites. Their diagenesis and intrusion by dolomite veins preceded the erosion and redeposition of the clasts into the diamictite.

The diamictite contains no diagnostic evidence of glaciation though a glacial origin cannot be definitely excluded. A debris flow mechanism of deposition is favoured.

There is no proof in the material examined that either the well preserved *Baicalia* specimens or the recrystallised stromatolitic dolomites, occurring in clasts in the diamictite, were derived from the Smithton Dolomite. The occurrence of *Baicalia* cf. *B. burra* is consistent with a late Precambrian age of the source rocks, and close comparisons can be made with the Skillogalee Dolomite of South Australia.

INTRODUCTION

Stromatolitic clasts have been found by one of us (B.J.G.) during geological mapping in a possibly late Precambrian diamictite overlying the Smithton Dolomite of northwestern Tasmania. Six samples collected from three separate localities (fig.1) on the BURNIE sheet area were examined by W.V.P. This paper discusses the evidence for the source of the diamictite and the significance of the stromatolites.

REGIONAL GEOLOGY

The geology of northwestern Tasmania has been summarised by Gee (1968) and by Turner (1973 unpublished), and of the Trowutta area by Longman and Matthews (1961).

Basic dykes of the Cooee Dolerite, dated by the K-Ar method at 720 m.y. (Richards, J.R. in Solomon & Griffiths 1974, p.21), intrude the Precambrian Cowrie Siltstone. The Cowrie Siltstone is in turn unconformably overlain to the north-east of Trowutta (fig. 1) by a thin quartz sandstone and conglomerate sequence, followed conformably by the Smithton Dolomite, a 1500 m thick dolomite-chert sequence. As no confirmatory Rb-Sr data are available, this date should probably be regarded as only a minimum age. The dykes are considered to be syntectonic with the Penguin Orogeny which has deformed the Cowrie Siltstone (Gee 1971). This deformation does not extend into the Smithton Dolomite, which is therefore probably younger than the dykes, but further geochronology would be desirable to fix the age of these.

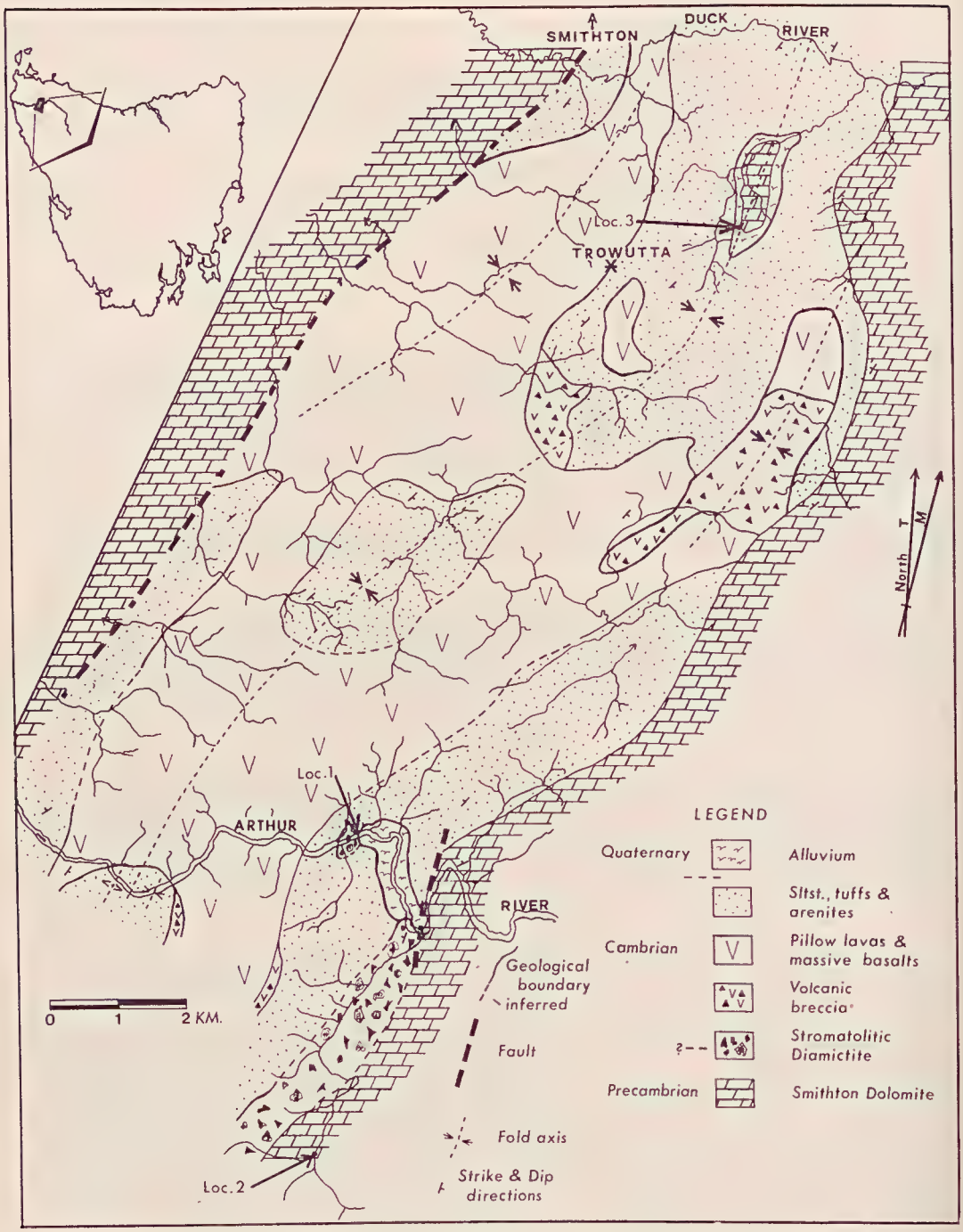

Fig. 1. Geological locality map of Trowutta area, northwestern Tasmania. The specimen localities are as follows:- (1) Spec. No. 94097; (2) Spec. Nos. 94099-94119; (3) Spec. No. 94098.

The Smithton Dolomite, mapped by B.J.G., consists of irregularly alternating beds of massive dolomite, oolitic dolomite, and horizons with desiccation cracks and stratiform stromatolites. It is overlain by a diamictite with stromatolitic clasts. In the Trowutta area (fig. 1) the diamictite is overlain by a sequence approximately 1500 m thick of interbedded tholeiitic lavas and dykes, mudstone and siltstone, with minor breccia and tuff. This sequence is correlated with the Dundas Group and is thus presumed to be Cambrian in age (Carey & Scott 1952). Such a correlation is supported by the presence of a late Middle Cambrian trilobite fauna (Gulline 1959) in a sedimentologically similar sequence that occurs ten kilometres to the west at Christmas Hills.

The diamictite is lithologically comparable to the Cottons Breccia of King Island, which possibly overlies unconformably granites that are 715-750 m.y. old, but this is not certain, and no fossils have been found in the overlying sediments (Jago 1974). Jago (1974) also presented arguments for and against a glacial origin of the Cottons Breccia.

The base of the Smithton Dolomite is regionally transgressive (Williams & Turner 1974). Three possible relationships between sections of the Smithton Dolomite and the diamictite at Trowutta and at Black River are shown in figure 2, and all of these are consistent with the present evidence.

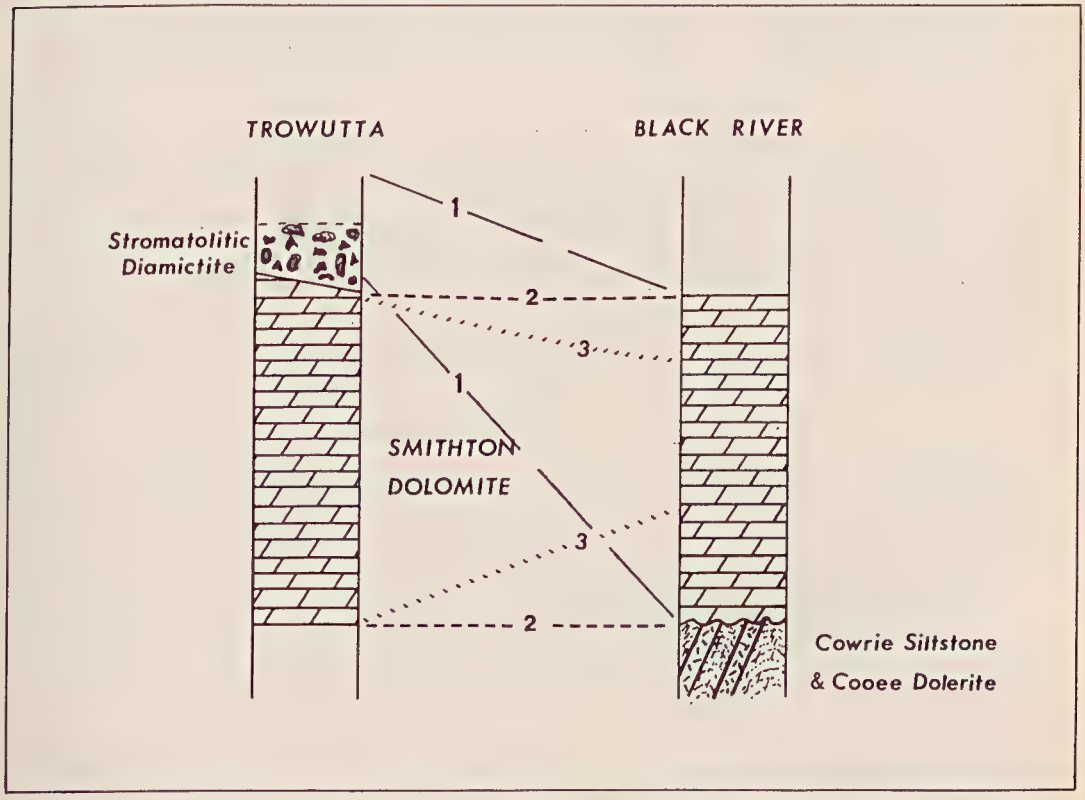

Fig. 2. Alternative correlations between sections at Trowutta and Black River.

Stromatolitic clasts in Precambrian diamictite, N.W. Tasmania

All Cambrian and older rocks in the Trowutta area have been affected by a low grade regional hydrothermal metamorphism. Most affected are the Cambrian tholeiitic lavas, which have been extensively spilitised with the development of prehnite-pumpellyite assemblages. The Smithton Dolomite has been variously metamorphosed on a local scale, and graditions from virtually unaltered massive dolomite to coarsely recrystallised dolomite may be observed in some areas over a distance of five metres. There is also partial or total replacement by chert, but it is not certain how much of this is a diagenetic effect and how much is due to metamorphism..

THE NATURE AND ORIGIN OF THE DIAMICTITE

The diamictite is texturally immature with clasts up to two metres long set in a matrix-supported framework. The clasts are generally unsorted and vary in shape from angular to subrounded with low degrees of sphericity (plate 1, figs. a, b). A crude stratification was observed in one outcrop, represented by poorly developed graded bedding repeated over one metre intervals. No other large scale sedimentary structures were observed.

The clasts are either dolomite or chert, the latter forming only 5-10% of the clast population. Of the dolomite clasts, 10-15% contain stromatolite structures, while the remainder are simply fine to medium-grained massive dolomites. The clasts range in size from the observed maximum of two metres in length to silt-sized particles. There is no apparent bias in clast size distribution. The matrix of the rock may be considered as the material of grain size less than 0.2 mm, and this fraction may compose up to 25% of the rock. Included in the matrix fraction are small ooids, often broken into radial segments, which resemble ooids present in parts of the Smithton Dolomite.

The textural immaturity and other features of the diamictite would be consistent with either a glacial or mudflow mechanism of deposition. The absence of glaciated (striated or facetted) clasts, the relatively restricted range of lithologies represented by t-e clasts, and the presence of crude graded bedding in one outcrop, tend to favour a submarine mass transport mechanism, although a glacial contribution cannot be definitely excluded. The source of the clasts was massive stromatolitic and cherty dolomite, and evidence is presented below that these clasts were lithified and veined prior to redeposition into the diamictite. On the other hand, the radially fractured individual ooid grains suggest the reworking of unconsolidated sediment. It is possible therefore that there were at least two separate sources for the detritus in the diamictite.

DESCRIPTION OF STROMATOLITE SAMPLES

Two types of stromatolitic carbonate are present in the assemblage of clasts examined by one of us (W.V.P.)

(1) Specimens 94097, 94098, and 94102-94119 are minimally recrystallised dark grey dolomites, in part siliceous, and all containing the same type of well preserved columnar stromatolites
(2) Specimens 94099, 94100 and 94101 are paler grey, more recry-tallised dolomites in which the stromatolitic lamination is only partially preserved. The Smithton Dolomite specimen (94120) is coarsely recrystallised and could be of higher metamorphic grade than the other samples.

The specimens described herein are stored in the collections of the Department of Geology, University of Tasmania.

Group *BAICALIA* Krylov, (1963:64)

Baicalia cf. *B. burra* Preiss (1972:80)
Material: Specimens 94097, 94098 and 94102-94119.

Description

Mode of Occurrence: This is unknown for the specimens provided since the stromatolites occur only in clasts and have not been located *in situ*. [*Baicalia burra* from the Flinders Ranges of S.A. occurs in thin tabular and domed biostromes, rarely in small discrete bioherms. Growth commences either from flat-laminated stromatolites, or on erosional surfaces. (Preiss 1972, p.81)]
Column Shape and Arrangement: Columns are tuberous, varying from sub-cylindrical to irregularly elongated, with round, oval and irregular traverse sections. Diameter of columns varies from 15 to 100 mm. Columns frequently show rapid expansions and constrictions (figs. 3a,d,e; pls. 2a; 3a; 5). The orientation of columns varies from vertical to inclined, in places nearly horizontal for short distances. Column axes are generally curved (fig. 3a; Pl. 2a).
Branching: The samples are of insufficient size to be fully representative of branching style (*Baicalia burra* shows a large range of variation of branching styles). Branches illustrated in reconstructions are slightly and markedly divergent (fig. 3a; pl. 2a).
Margin structure: The lateral surface of columns is generally smooth but in places short peaks overhang the margin. Generally laminae approach the margin at a high angle, and terminate without appreciable thinning. Locally the laminae thin and coat the margin so as to form a patchy wall (e.g. pl. 5a, Specimen 94118); this occurs only where the laminae are steeply convex.
Lamina Shape: Lamina shape is mostly gently to moderately convex, but varies even in single columns from very gently convex to steeply convex. Seventy percent of the laminae measured have ratios of h/d between 0.2 and 0.5. As with *Baicalia burra*, the mode falls in the interval 0.3-0.4. The laminae are very smooth, and of even, uniform curvature, except where they overlie contemporaneous erosional surfaces (micro-unconformities). The shape of laminae shows a high degree of inheritance, except at micro-unconformities, which are common in all specimens. Micro-unconformities are observed to have a maximum erosional relief of about a centimetre. Some typical lamina shapes are illustrated in Fig. 3b.
Microstructure: The lamination is generally well preserved and comprises alternating very distinct, continuous light and dark laminae. This type of microstructure is termed "banded". Both types of laminae are continuous across the full width of columns, except where cut by micro-unconformities. The dark laminae consist of micritic ferroan dolomite, enriched in organic matter, and partly pyritic. They represent probable original successive sheet-like algal mats in which carbonate mud was either trapped or precipitated by algal filaments. Their thickness varies from about 30μm to 20μm, but in places thicker dark bands, up to a millimetre thick consist of sets of very fine light-dark lamination pairs. These sets are termed "macrolaminae" (e.g. pl. 5a). No algal filaments are preserved in the dark laminae, however there are streaky, wispy concentrations of organic matter within them, generally parallel to the lamination but finely wavy and locally oblique. These resemble the lamination fabrics of certain dolomitic stromatolites which are microfossiliferous where silicified. It is suggested that this fabric results from the trapping of carbonate mud by an algal mat whose filaments lie sub-parallel to the lamination. The presence of recumbently overfolded sections of some laminae suggests that they were cohesive, of rubbery consistency (as if often observed with Recent algal mats) and only loosely attached to the underlying laminae. The presence of rounded carbonate grains of fine sand size (detrital?) in some dark laminae, with the wispy concentrations of organic matter draped around them, is suggestive of trapping and binding action by algal filaments. However, precipitation of carbonate within the algal mats, due to changes in micro-environment caused by algal photosynthesis, is known in Recent mats and was probably

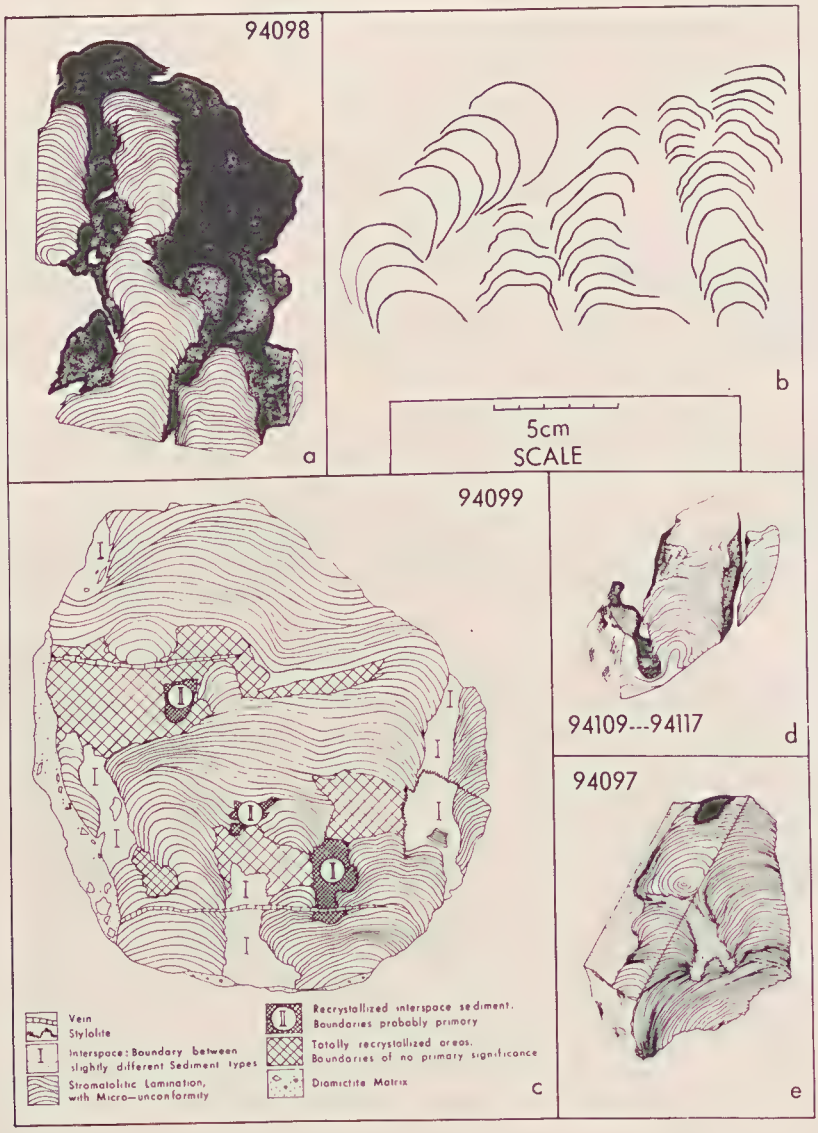

Fig. 3. Stromatolites from the Smithton-Trowutta area. Note: The 50 mm scale bar applies to all drawings.
(a) Reconstruction of *Baicalia* cf. *B. burra*, specimen No. 94098; (b) representative examples of lamina shapes of *Baicalia* cf. *B. burra*; (c) boulder of recrystallised stromatolitic dolomite in diamictite matrix; (d) drawn from acetate peel; specimen No. 94099; reconstruction of *Baicalia* cf. *B. burra* using serial slabs, specimen Nos. 94109-94117; (e) sketch of *Baicalia* cf. *B. burra*; the lightly stippled area represents interspace sediment; note the pronounced micro-unconformities; specimen No. 94097

important in the Precambrian (Monty 1973). There is no evidence as to whether trapping or precipitation was the dominant factor in the building up of these stromatolites.

The intervening light laminae consist of clear sparry dolomite. Unlike the dolomite of the dark laminae, it remains unstained by potassium ferricyanide and is therefore a relatively pure dolomite. The light laminae are of xenotopic, roughly equigranular texture, of grain size 20 to 60 μm. Their thickness varies from 50 to 500 m and in places gradations can be observed at the tops of dark laminae which suggest that the boundaries have been slightly recrystallised (pls. 5a; 6a, b).

Relationships at micro-unconformities (pls. 5a; 6a, b) suggest that the eroded surface of the stromatolite was somewhat irregular and that the overlying lamina was draped over the irregularities. This left void spaces whose sparry infilling is often continuous with the sparite of the light laminae. It is possible that the light laminae were originally entirely void, being formed by the lifting of the growing surface mat from its substratum. Where one light lamina truncates an underlying light lamina the evidence is equivocal; in places the sparite is continuous between the two, and in other places, the younger sparite is distinct and demarcated from the older by lines of impurities or changes in texture (pl. 5a). This evidence could be interpreted in two ways:-

(1) The sparite is an open-space filling which was precipitated in place soon after the formation of void, and was itself subject to penecontemporaneous erosion.

(2) The sparite represents a primary lamina of relatively pure carbonate which was later locally subject to recrystallisation.

Interspaces: These are filled everywhere with randomly packed intraclast grainstone. The intraclasts are small broken fragments of the algal mats forming the columns; they similarly consist of ferroan dolomite. In places at column margins, gradations can be observed where the dark laminae have spalled off the column and were preserved in the process of being incorporated into the interspace sediment. There are also larger angular fragments eroded from the stromatolite in which the sparry laminae are fully developed. In this case at least, they pre-date pene-contemporaneous erosion. In places, there are subrounded pellets, 0.1 - 0.2 mm in diameter, probably themselves comminuted intraclasts. The intraclasts are cemented by, and partly recrystallised to sparry pure dolomite; in places there are two generations of cement, an earlier drusy and a later blocky phase.

The interspaces appear to contain no micrite or other muddy sediments. The winnowed, grain-supported nature of the sediment suggests accumulation under high energy conditions.

Secondary Alterations :

(1) Penecontemporaneous. Like the stromatolites of the Skillogalee Dolomite, South Australia, these are entirely dolomitic. It is uncertain whether this reflects syndepositional dolomitisation of lime mud sediments, perhaps associated with dolomitic cementation, or whether the muds that were trapped by the algal mats were already colomitic. The total absence of remnant calcite and extremely fine texture of the dolomite in these cases argue against a later diagenetic origin of the dolomite. Indeed the excellent preservation of fine lamina detail is suggestive of the original sediment being dolomite. Actively growing algal mats were probably only loosely attached to their substrata, and the void spaces were filled with sparry dolomite at an early stage, in any case often prior to contemporaneous erosion, which may have taken place during storms.

(2) Diagenetic. The stromatolites are patchily silificied in some specimens. Unlike the black cherts replacing carbonate in the Skillogalee Dolomite however, the silica here has not preserved the detailed primary structures well. The chert is medium grey in colour and of microcrystalline, xenotopic texture, grain size 10-15 mm. It tends to follow the lamination broadly, preferentially replacing either the sparry or the dark laminae but also transgressing across the lamination in detail. The chert

is very patchy and does not appear to be prospective for finding microfossils; however if any samples could be found which are completely silicified to a dense black chert with well preserved lamination, these would warrant careful examination.

Partial recrystallisation of dolomite has been mentioned above. This has affected both light and dark laminae in certain cross-cutting areas. Incipient recrystallisation of some parts of dark laminae has produced very minor grumous textures. Locally, irregular vughs (possibly due to solution) are partially or wholly filled with coarse drusy quartz (Pl. 7a).

Comparisons

The stromatolites readily fall into the group *Baicalia* on the basis of column shape, branching style, surface morphology and microstructure. They particularly resemble *Baicalia burra*, especially in specimens from the Willouran Ranges, S.A. where the preservation of the lamination and the nature of the interspace sediments are closely comparable. A lithological difference is that the dolomite forming the Skillogalee Dolomite stromatolites is not notably ferroan. The nearest known occurrence of South Australian *Baicalia burra* is in the vicinity of Burra, but here the interspace sediments are dominantly dolomicrites and the preservation is poorer due to low grade regional metamorphism. Because of the mode of occurrence and large-scale structure of the Tasmanian stromatolites is not known, they are referred to *Baicalia* cf. *B. burra*.

Unclassified Poorly Preserved Stromatolites

Specimen No. 94120 (Smithton Dolomite):- This is a rather coarsely recrystallised, medium grey, stratiform-stromatolitic dolomite (average grain size about 0.1 mm). The lamination is preserved only in a general way by slight contrasts of pigmentation but without marked changes in grain size across lamina boundaries. Near its natural weathering surface the specimen shows selective leaching of some laminae. It is cut by very coarse dolomite veins and irregular nodules. The primary microstructure is very poorly preserved and is therefore impossible to compare with that of other stromatolites (pl. 2b).

Specimens 94099 and 94101 are pale to medium grey dolomites of a degree of recrystallisation intermediate between that of the *Baicalia* specimens and that of specimen 94120. A peel made from 94099 is illustrated diagrammatically in figure 3c. In the areas of the peel in which primary stromatolitic lamination is preserved the microstructure may have originally been banded but is now far more recrystallised than that of the well preserved specimens. The dark laminae are wispy, lenticular, about 0.1 mm thick; light laminae are more continuous, up to 1 mm thick, and consist of 20-30 μm grain size xenotopic dolomite, and in part ferroan dolomite.

The gross morphology is only partly columnar, but passes upwards into stratiform stromatolites. Over large areas the primary boundaries of columns are obliterated by recrystallisation; where margins are preserved they are unwalled but relatively smooth. Interspaces are filled with more or less recrystallised dolomite (originally micritic?) incorporating both structureless intraclasts and laminated stromatolite fragments. In places the interspace sediments are completely recrystallised to a very coarse, sparry mosaic. Bedding is locally expressed in the interspaces by slight changes in silt content (fig. 3c). Dolomite veins and stylolites cut the whole rock and post-date its lithification. They definitely pre-date the erosion and redeposition of the clast.

SIGNIFICANCE OF THE STROMATOLITES

The following facts may be stated with some confidence:-

(1) The stromatolitic clasts were derived from the erosion of a completely lithified dolomite, appreciably older than the diamictite containing the clasts.

they are not intraformational.

(2) The well preserved stromatolites closely resemble *Baicalia burra* known from the Skillogalee Dolomite of Torrensian age from the Adelaide Geosyncline.

(3) *Baicalia burra* is similar to *B. maica* Nuzhnov, known from the uppermost Middle Riphean of the U.S.S.R., dated about 950 - 1000 m.y.

(4) *Baicalia* has so far never been reported from rocks younger than about 700 m.y.

Any interpretation of these facts is however, hihghly tentative and controversial. It must be based on certain assumptions which should be clearly stated:

(1) that individual stromatolite taxa have restricted time-ranges. (Opinion on this issue is still divided).

(2) that the time ranges of the taxa that have been worked out in the U.S.S.R. an be duplicated also on other continents. (There is an indication that they may be duplicable, but this is not yet proven).

(3) that the time ranges of specific stromatolite forms will be the same as those of very closely related, but distinguishable forms.

These three assumptions would lead to the conclusion that both the Skillogalee Dolomite, and the dolomite from which the clasts were eroded, are about 1000 m.y. old. The following arguments should be weighed against this conclusion:-

(1) The data of Cooper and Compston (1971), if proved correct, would indicate that the Skillogalee Dolomite is younger, perhaps considerably younger, than 870 m.y. This would also affect the age interpretation of the Tasmanian stromatolites if a correlation with the Skillogalee Dolomite is maintained.

(2) *Baicalia burra* is not strictly comparable to any Russian stromatolite taxa at form level. Therefore the time ranges need not necessarily be identical. Other forms of *Baicalia* do range up into the Late Riphean (950 to 680 m.y.) in the U.S.S.R. and North Africa.

CONCLUSIONS

Recent work by B.J.G. has shown that a major hydrothermal metamorphic event occurred after the eruption of the Cambrian volcanics. The "spilitisation" of the volcanics to prehnite-pumpellyite assemblages in the Trowutta area has affected rocks as far as the coast at Smithton and south to the Arthur River, indicating metamorphism of regional extent. The metamorphic effects may be traced down into the Smithton Dolomite, which has been variously recrystallised, as discussed above. The variable degree of recrystallisation in the clasts is comparable to that seen in the Smithton Dolomite, and cannot therefore be used to argue against the Smithton Dolomite being a source of the clasts in the diamictite.

However, the stromatolitic clasts show evidence of being lithified, veined, and affected by stylolitic pressure solution prior to erosion and redeposition into the diamictite. On the other hand, fractured individual ooids, similar to ooids found in the Smithton Dolomite, suggest reworking of unconsolidated or only poorly consolidated sediment from the Smithton Dolomite into the diamictite. The Smithton Dolomite contains stratiform stromatolites, but *Baicalia* cf. *B. burra*, found in the clasts, has not been located in it. Therefore there is the possibility of at least two sources for the constituents of the diamictite: unconsolidated Smithton Dolomite and consolidated older dolomites. The stromatolites themselves do not provide any evidence that the Smithton Dolomite was the source of the stromatolitic clasts.

The identification of *Baicalia* cf. *B. burra* is consistent with late Precambrian age for the source of the clasts. If certain assumptions are accepted, the range may be less than about 1000 m.y. and greater than about 700 m.y. The clasts could have been derived from a correlative of the Skillogalee Dolomite of South Australia, or a southerly extension of it. If their source was local, it would support an origin by a debris flow mechanism for the diamictite. On the other hand, a distant source such as

the Skillogalee Dolomite would favour a hypothesis of glacial transport for at least some of the clasts. At this stage, it is not possible to resolve conclusively which of these alternatives is correct. The Smithton Dolomite acted as a local source of relatively unconsolidated detritus reworked into the diamictite in addition to the lithified stromatolitic clasts.

ACKNOWLEDGEMENTS

The residents of the Trowutta area are thanked for their help during the mapping of the area. Mr. M.R. Banks and Dr. E. Williams are also thanked for their discussions and criticisms of this paper. The paper is published with the permission of the Director of Mines, South Australian Mines Department.

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PLATE EXPLANATIONS

Plate 1 : (a) Polished surface of hand specimen of stromatolitic diamictite showing angularity and size range of clasts.

(b) Thin section viewed in transmitted light showing angularity and size range of clasts, one of which (large and central) is of a stromatolitic fragment.

Plate 2 : (a) Slab of *Baicalia* cf. *B. burra* (spec. no. 94098). The columns have been outlined in Indian ink and reference lines drawn at right angles on the slabs to facilitate three-dimensional reconstruction (see fig. 2a). Scale is graduated in millimetres.

(b) Polished slab of Smithton Dolomite (spec. no. 94120), consisting of stratiform stromatolites with poorly preserved lamination.

(c) Broken fragment of stromatolitic boulder containing *Baicalia* cf. *B. burra* spec. no. 94102). The relatively darker laminae have been stained deep blue by potassium ferricyanide, indicating that they are composed of ferroan dolomite.

Plate 3 : (a) Broken fragment of a stromatolitic boulder illustrating weathered surface.
Baicalia cf. *B. burra*. (spec. no. 94104-94105).

(b) Broken fragment of a stromatolitic boulder illustrating the distinctly banded microstructure of *Baicalia* cf. *B. burra* on weathered surface. (spec. no. 94109).

Plate 4 : (a) Stained acetate peel of partially silicified dolomite boulder containing *Baicalia* cf. *B. burra*. (spec. no. 94097). The dark laminae are composed of ferroan dolomite, stained deep blue by potassium ferricyanide (i.e. scale in centimetres).

(b) Etched slab of the same specimen from which the acetate peel was taken. The irregular very dark patches (which appear blank on the peel) are solicified. (Scale in millimetres).

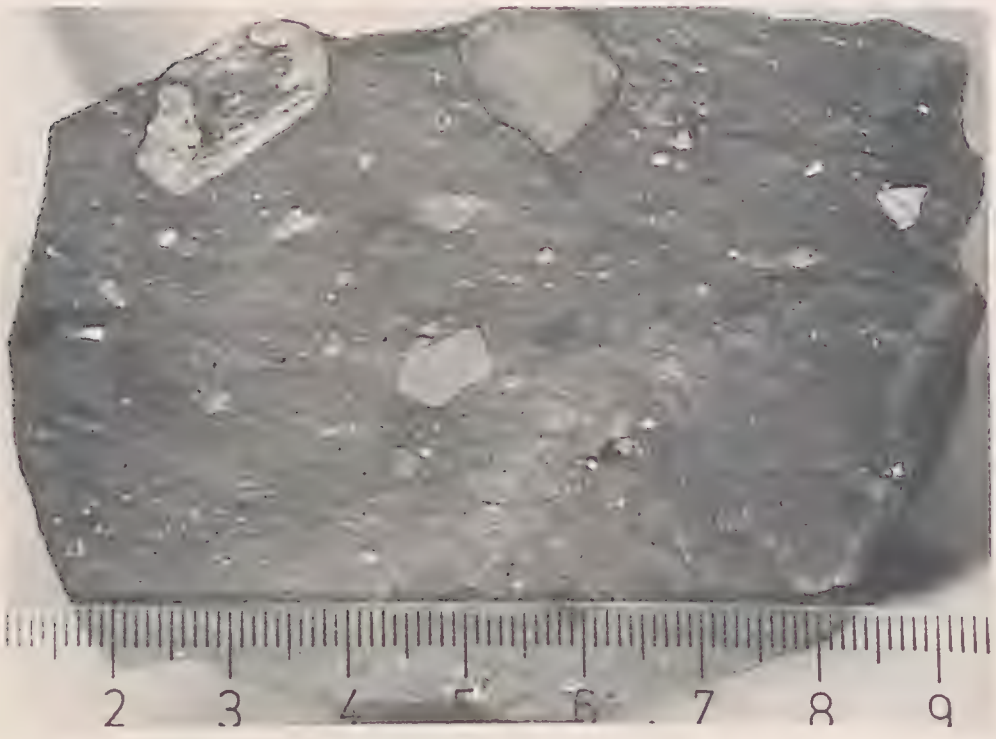
Plate 5 : (a) Thin section of *Baicalia* cf. *B. burra* (spec. no. 94118) illustrating the banded microstructure of alternating ferroan dolomite dark laminae and sparry pure dolomite laminae, micro-unconformities and local development of a wall at column margin. (in lower right corner). (Scale in millimetres).

(b) Large stained acetate peel of recrystallised stromatolitic boulder in diamictite matrix (dark area at right). The structures visible are illustrated in fig. 3c. (Scale bar in centimetres).

Plate 6 : (a) Thin section of *Baicalia* cf. *B. burra* illustrating banded microstructure with micro-unconformities. (Scale in millimetres). spec- no. 94119b).

(b) Stained acetate peel of another part of the same specimen (94119a). The dark laminae are composed of ferroan dolomite. In places laminae appear to be overfolded suggesting a cohesive flexible consistency of the algal mats. (Scale in millimetres).

A.



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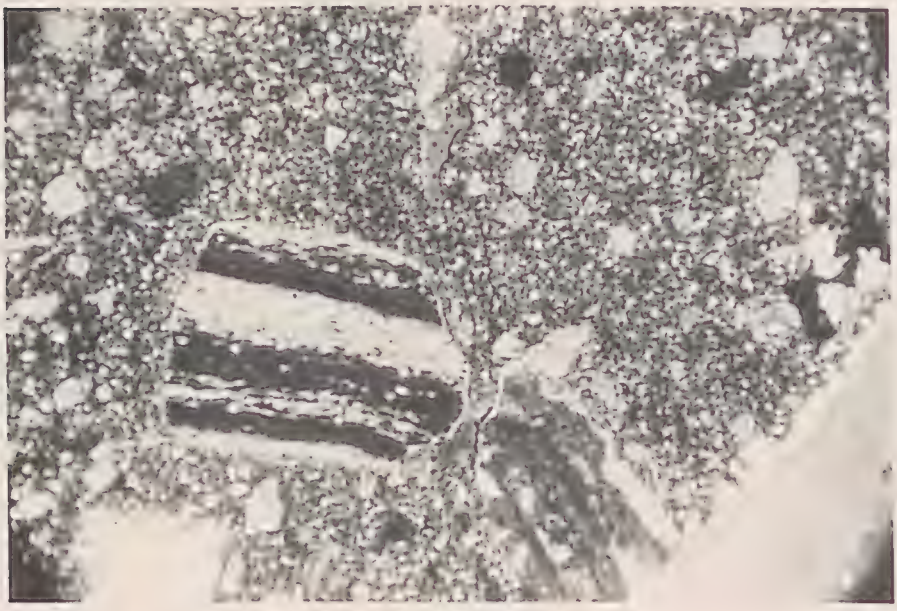

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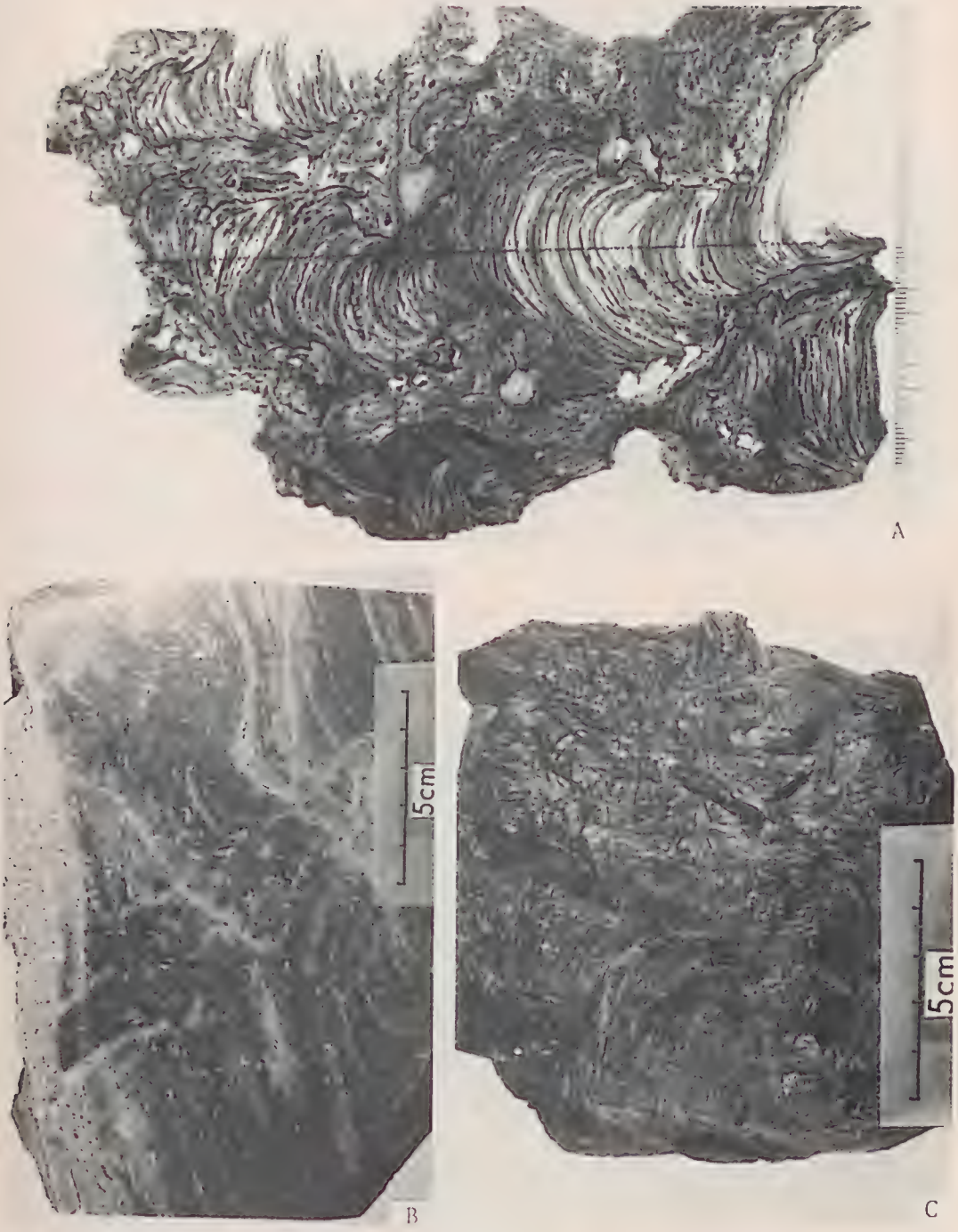

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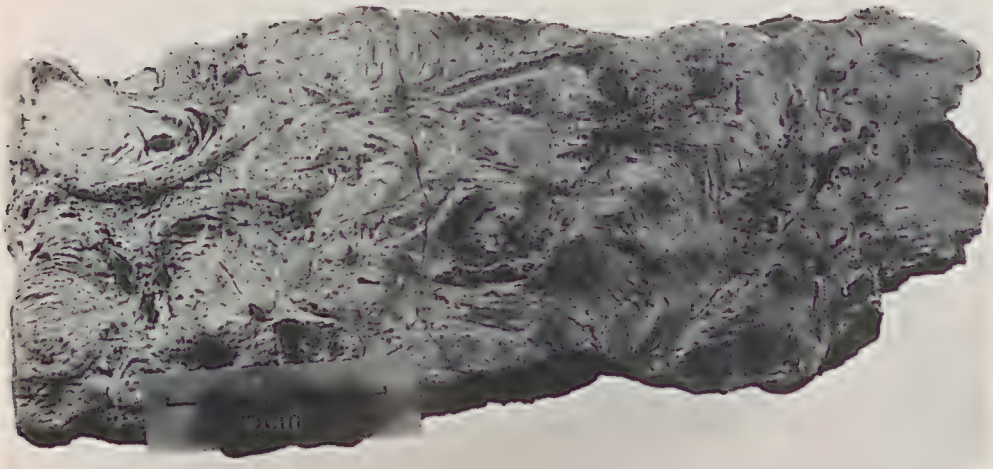

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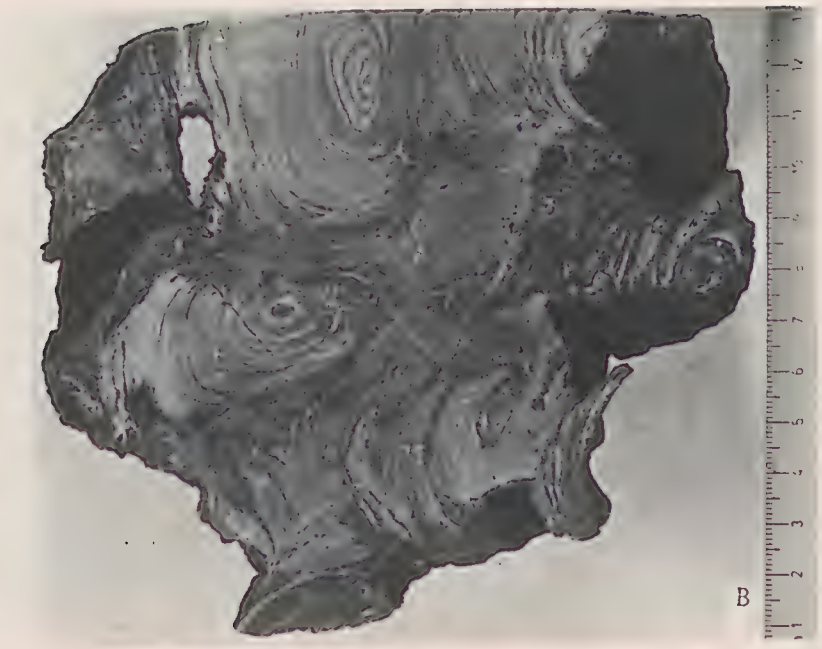
PLATE 3



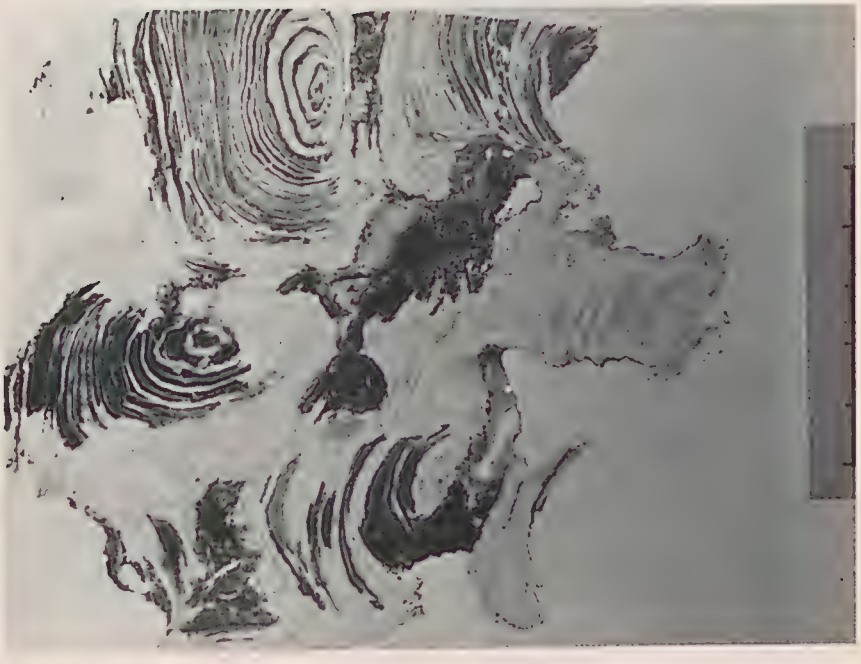
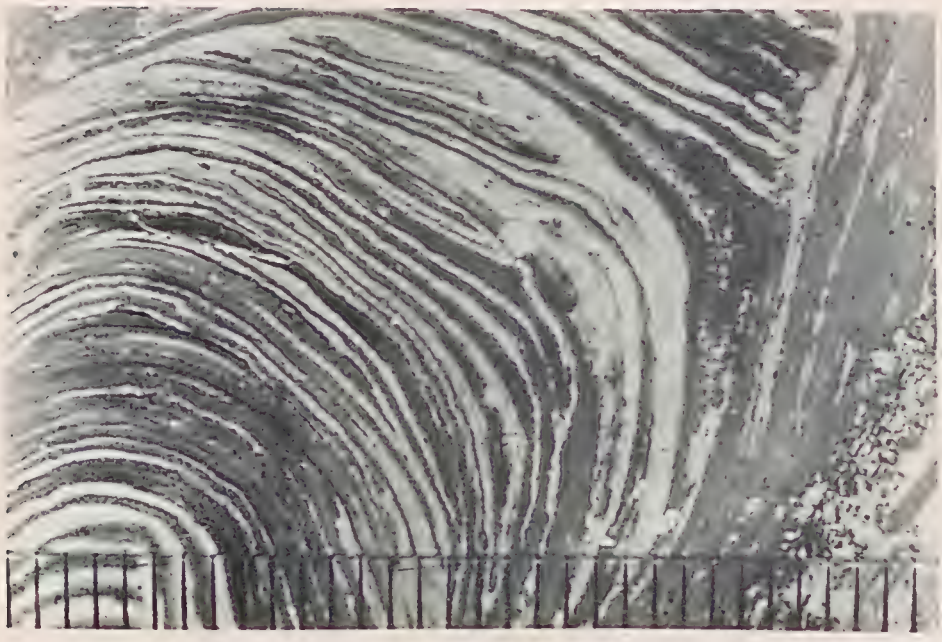


PLATE 4

Stromatolitic clasts in Precambrian diamictite. N.W. Tasmania

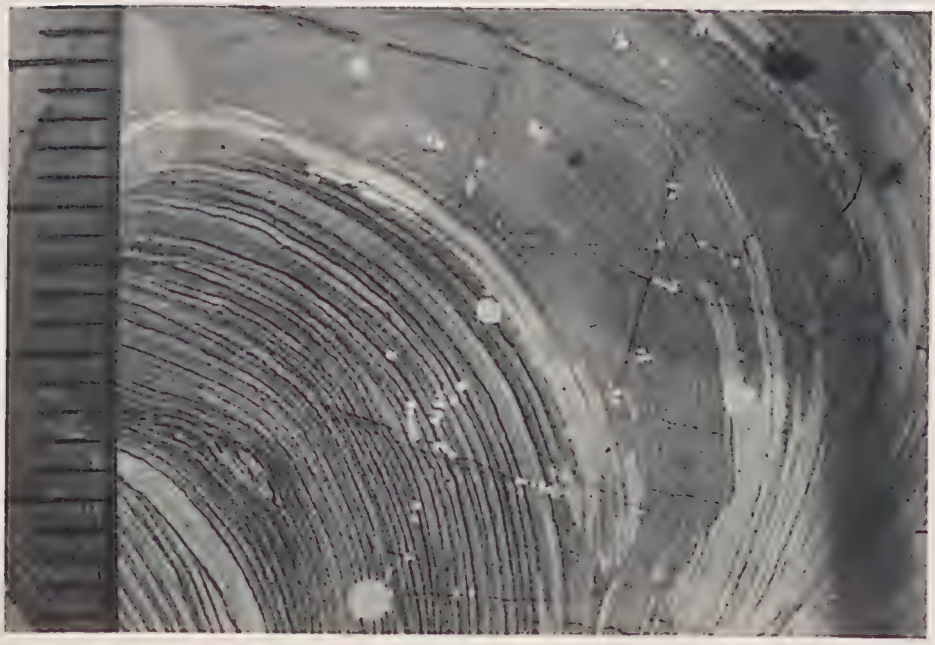


A

B

PLATE 5

A



B

PLATE 6

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(ms. received 1.3.1976)

CLATHRODICTYON AND *ECCLIMADICTYON* (STROMATOPOROIDEA) FROM THE ORDOVICIAN OF TASMANIA

by B.D. Webby, University of Sydney

and M.R. Banks, University of Tasmania

(with three plates)

ABSTRACT

Five species of late Ordovician clathrodictyid stromatoporoids are described and illustrated from Tasmania. Of these, three are new species of *Clathrodictyon*—*C. idense*, *C. molense* and *C. plicatum*—and a fourth is a new species of *Ecclimadictyon*—*E. undatum*. They come from localities in the Mole Creek, Ida Bay and Florentine Valley areas, from horizons towards the top of the Gordon Limestone Subgroup.

INTRODUCTION

Apart from the early record of the Ordovician stromatoporoid *Stromatocerium* sp. ind. from west Tasmania (Bigsby 1868), there is virtually no further recognition of the group until Banks (1957), and Banks & Johnson (1957) drew attention to stromatoporoids in the 'Gordon Limestone' of the Florentine Valley area, Loongana, Moina and Eugenana. Subsequent records include Banks' (1962; 1965) identification of aulacerids, *Cryptophragmus* and *Thamnobeatricea*-like forms from various localities in the limestone, and Banks' (1971) reference to the 'Chazyan' association of *Stromatocerium* with *Maclurites* and *Girvanella*. Webby (1971, p.13) also mentioned the presence of a cylindrical form having an *Alleynodictyon*-type structure, and Corbett and Banks (1974) listed *'Thamnobeatricea'*, a form close to *Stromatocerium rugosum*, *Aulacera* sp. and a *Clathrodictyon*-like form from the Florentine Valley area, together with providing the first illustration of an Ordovician stromatoporoid (cf. *Thamnobeatricea)* from Tasmania.

The majority of the stromatoporoids in the Gordon Limestone Subgroup of Tasmania are labechiids not clathrodictyids. Only five species of clathrodictyids — those described herein — have so far been recognized. The clathrodictyids are confined to the uppermost part of the Gordon Limestone Subgroup in the Mole Creek area and elsewhere. *Clathrodictyon plicatum* sp. nov., *Clathrodictyon* sp., and *Ecclimadictyon undatum* sp. nov. occur at The Den, 3.5 km west-north-west of Mole Creek (Mersey 1: 100,000 sheet 8114, edit. 1, series R661; Grid ref. DQ483010). *C. plicatum* and *E. undatum* have also been found in the large working quarry farther west (Grid ref. DQ466027), and *C. plicatum* from west of the road leading to the quarry (Grid Ref. DQ463023). Another species, *C. molense* sp. nov., occurs together with *E. undatum* at a locality on the north-east side of the road leading to the quarry (Grid ref. DQ465020). *E. undatum* also comes from the Benjamin Limestone (upper part of Gordon Limestone Subgroup) at a locality east of the Westfield Syncline, approximately 0.8 km south-east of the Westfield Road (co-ordinates 444.650E, 751.330N). A fifth species, *C. idense* sp. nov., has been collected from the Gordon Limestone Subgroup near Ida Bay. Unfortunately the precise horizon and location are unknown. It seems most likely to have come from an horizon high in the limestone, possibly from the site of the main quarry on the north-east slopes of Marble Hill (Tasmania topographic series 1:31,680, Southport sheet no. 8211-II-S; Grid Ref. 764E, 650N).

Most of the Tasmanian species of *Clathrodictyon* and *Ecclimadictyon* are new, and

are distinct from those described from the late Ordovician of New South Wales (Webby 1969). It is difficult therefore, on the basis of these faunas alone, to suggest a likely correlation between the Tasmanian clathrodictyid-bearing limestones and those of New South Wales. In N.S.W. the first clathrodictyids appear at the base of Fauna II and persist through Fauna III. It seems unlikely, however, from other faunal data and correlations that the occurrences, restricted to the top of the respective 'Gordon Limestone' sequences, come from horizons older than Fauna III. Differences between the Tasmanian and N.S.W. clathrodictyid faunas may be accounted for either (1) by the Tasmanian fauna being slightly younger than the N.S.W. Fauna III (perhaps being equivalent to the non-carbonate interval of the Malachi's Hill Beds between Faunas III and IV, or (2) by the differing tectono-environmental settings of the Tasmanian Shelf and the Macquarie Volcanic Belt (Webby 1976) during Fauna III time (i.e., late Eastonian-early Bolindian time).

SYSTEMATIC PALAEONTOLOGY

The registration numbers of specimens in the University of Tasmania, Department of Geology fossil collections have the prefix UTGD.

Family Clathrodictyidae Kühn, 1939
Genus *Clathrodictyon* Nicholson & Murie, 1878

Type species. *C. vesciculosum* Nicholson & Murie, 1878

Clathrodictyon idense sp. nov.
Pl. I, figs. 1-2

Material. Holotype (UTGD 58125) from Gordon Limestone Sub-group south-west of Ida Bay. Precise horizon and location near Ida Bay unknown.

Description. Fragment of massive, sheet-like coenosteum measuring 70 x 15 mm across and 50 mm in height. Laminae are regular, continuous, and only very gently undulating; spaced from 10-12 mm in 2 mm vertically; and of variable thickness, typically from 0.03-0.1 mm. Pillars vertical, and cylindrical to spool shaped, usually extend across interlaminar space; rarely incomplete; only occasionally superposed; vary in diameter from 0.05-0.2 mm; spaced from 0.2-0.5 mm apart laterally. Galleries rounded to elongate, may be up to 0.2 mm high and 0.1-1.0 mm wide, but at certain levels in coenosteum of more closely spaced and thickened laminae, galleries may be constricted or completely infilled; zones of thickening usually laterally continuous but not always. Occasional thin, curved, inclined plates subdivide galleries; these are dissepiments, and they are especially conspicuous in tangential section showing as arcuate lines linking pillars. Astrorhizae not observed. Microstructure compact.

Remarks. No other Australian Ordovician species of *Clathrodictyon* is closely similar to *C. idense*.

Clathrodictyon molense sp. nov.
Pl. I, figs. 3-6.

Material. Holotype (UTGD 94622) from upper part of the Gordon Limestone Sub-group on north-east side of road to limestone quarry, 5 km WNW of Mole Creek.

Description. Coenosteum massive, low conical, 110 x 80 mm across and 40 mm in height; only weakly folded in some parts of this fine textured coenosteum. Laminae minutely crumpled and downwardly deflected at junctions with pillars; identity of individual layers laterally persistent but not individual laminae; spacing of laminae from 14-18 per 2 mm vertically; thickness of laminae 0.03-0.05 mm. At base of coenosteum, first few rows of laminae notably irregular; also a few bands of more closely spaced laminae at intervals through coenosteum. Pillars cylindrical, confined to interlaminar space, not normally superposed; from 0.05-0.1 mm in diameter; spaced from 0.1-0.3 mm apart; isolated crossing galleries, but form incomplete

meshes adjacent to contacts with laminae. Galleries rounded to elongate, up to 0.2 mm high; of variable length, usually 0.1 mm high and about 0.4-0.5 mm long; in extremes up to 1.3 mm long. No astrorhizae. In better preserved parts of coenosteum compact microstructure is shown.

Remarks. *C. molense*, of Ordovician species of *Clathrodictyon*, is quite distinct. It shows a resemblance to the Estonian Llandoverian *C. sulevi* Nestor, 1964, but is much finer textured, having 14-18 laminae per 2 mm, as compared with 10-12 laminae per 2 mm in *C. sulevi*. Also the Estonian species has small astrorhizae.

Clathrodictyon plicatum sp. nov.
Pl. II, figs. 1-5

Material. Four specimens (UTGD 94623-26) from locality west side of road leading to limestone quarry, 5 km WNW of Mole Creek. One specimen (UTGD 94627) from limestone quarry, 5.5 km WNW of Mole Creek. Four specimens (UTGD 94628-29, 94631-32) from The Den, 3.5 km WNW of Mole Creek. Holotype is UTGD 94626; other numbered specimens designated paratypes. All specimens from upper part of Gordon Limestone Sub-group.

Description. Laminar, sheet-like to encrusting; often showing intertonguing relationships with surrounding sediment; largest specimen (UTGD 94624) measures 80 x 70 mm across and 60 mm high. Mamelons prominent, spaced from 2-7 mm apart; of variable height. Latilaminae also conspicuous, vary from 0.5-11 mm high; mamelons may be continuous through more than one latilamina. Laminae mainly regular and laterally continuous; folded evenly across mamelons; usually spaced from 9-14 in 2 mm vertically and vary from 0.02-0.07 mm thick; in a few areas of coenosteum where laminae are more widely spaced than normal, galleries become occupied by dissepiments (or secondary laminae). Within part of laminar, sheet-like coenosteum of UTGD 94631 (Pl. II, fig. 5) there are mamelon-like upgrowths which exhibit an inner, axial core filled with zigzag, secondary laminar tissue and interspersed regular laminae - a *Plexodictyon*-type structure; this grades into regular *Clathrodictyon* form with vertical pillars confined to an interlaminar space in marginal areas. Possibly the inner, axial zone grew more rapidly than the flanking marginal areas. Pillars cylindrical, spindle and inverted conical; these latter spread upwards to meet laminae leaving a triangular space between them; confined to one interlaminar space; rarely superposed; pillars mainly 0.05-0.1 mm in diameter; spaced 0.1-0.3 mm laterally. Occasional astrorhizal tubes associated with mamelons; diameter about 0.2 mm. Also a few rare rounded foreign bodies or tubes, 0.7-1.0 mm across, in positions near base of latilaminae, which have caused laminae to updome over them. Microstructure compact.

Remarks. *C. pilatum* has a similar morphology to *C.* aff. *mammillatum* (Schmidt) from the late Ordovician of New South Wales (Webby, 1969), but has narrower spacing of laminae (9-14 in 2 mm as compared with 6-9 per 2 mm in *C.* aff. *mammillatum*). Compared with the second N.S.W. late Ordovician species, *C.* cf. *microundulatum* Nestor, it has a more markedly mammillated form, and the pillars, usually confined to a single interlaminar space, include inverted conical forms.

Clathrodictyon sp.
Pl. III, figs. 4-5

Material. Three specimens (UTGD 94633-35) from The Den, 3.5 km WNW of Mole Creek; upper part of Gordon Limestone Sub-group.

Description. Coenosteum columnar, comprising a series of interconnected cylinders forming in tangential section branching to chain-like patterns with the sediment. Cylinders probably merely represent extended mamelon columns; spacing usually from 10-35mm laterally, measured between centres of cylinders. Largest specimen (UTGD 94634) measures 100 x 80 mm across, and columns at least 120 mm in height. Axial zone of cylinders destroyed by recrystallization; calcite infilled. Commensal tubes

ramify through coenosteal tissue of middle-outer parts of cylinders; from 0.3-0.6 mm wide and with horizontal to slightly sagging tabulae (spaced about 7 per 2mm). Latilaminae also frequently occur in outer parts of coenosteum; 1-6 mm wide. Laminae most variable; may be evenly spaced and regular at some levels within coenosteum, but in others interlaminar spaces widen and become infilled with irregular, crumpled laminar tissue (dissepiments or secondary laminae); usually 11-13 per 2 mm vertically; thickness of laminae typically from 0.03-0.07 mm. Pillars normally confined to one interlaminar space, cylindrical to spindle shaped; occasionally with upwardly spreading form leaving space between forks and the overlying lamina; usually from 0.03-0.1 mm in diameter, and spaced about 0.1-0.2 mm apart. No astrorhizae seen, but may have been confined originally to centres of cylinders, now recrystallized and calcite infilled. Microstructure compact.

Remarks. Although closely similar to *C. pilatum*, *C.* sp. exhibits a markedly different columnar growth form, and slightly more prominently crumpled or zigzagged laminae.

Genus *Ecclimadictyon* Nestor, 1964
Type species. *Clathrodictyon fastigiatum* Nicholson, 1886

Ecclimadictyon undatum sp. nov.
Pl. III, figs. 1-3

Material. Holotype (UTGD 94636) from north-east side of road to limestone quarry, 5 km WNW of Mole Creek. Paratype UTGD 94637 from limestone quarry, 5.5 km WNW of Mole Creek; and paratype UTGD 90917 from the Den, 3.5 km WNW of Mole Creek, uppermost part of Gordon Limestone Sub-group. Paratype UTGD 94638 from locality off track, south-east of Westfield Rd. and east of Westfield Syncline, Florentine Valley area; Benjamin Limestone of Gordon Limestone Subgroup (Corbett and Banks, 1974).

Description. Coenosteum consists of latilaminate, irregularly undulating sheet-like mass, 130 x 110 mm across, and up to 70 mm in height. Preservation indifferent; structure of parts of coenosteum, especially interiors, has been obliterated, and small areas show tectonic distortion. Laminae zigzag shaped, evenly spaced, from 12-14 per 2 mm vertically; at base of latilaminae laminar tissue shows much irregularity; laminae usually about 0.05-0.08 mm thick. Pillars normally confined to interlaminar space; very rarely superposed; formed from downward inflexions of laminae; about 0.07-0.1 mm in diameter; in tangential sections, pillars appear as isolated dots, and with laminae as bars and open to closed meshes. No astrorhizae seen. Compact microstructure exhibited in a few small areas of good preservation, but usually shows a secondary three-layered structure composed of a central, clear zone with darker granular margins to either side.

Remarks. In comparison with Late Ordovician *E. amzassensis* (Khalfina 1960) from the upper part of the Cliefden Caves Limestone of central New South Wales (Webby 1969), *E. undatum* has less vertically continuous pillars, a closer spacing of laminae (12-14 per 2 mm, as contrasted with 8-12 in *E. amzassensis*), a more undulating, sheet-like, latilaminate form, and no astrorhizae. A second Ordovician species, *E. nestori* Webby 1969, also from the upper part of the Cliefden Caves Limestone, differs in being a finer textured form (15-16 laminae in 2 mm) and showing bunchy astrorhizae. Another N.S.W. species, *E.* sp. nov. (Webby & Morris, in press) from a limestone breccia in the upper part of the Malongulli Formation, has similar spacing of laminae but differs in having more sharply zigzagged laminae with gaps in lateral continuity which suggest they may form, in part, rod-like, as well as sheet-like laminar tissue. Also the coenosteal tissue generally is slightly thicker in *E. undatum* than in this N.S.W. species. The widely distributed type species *E. fastigiatum* (Nicholson 1886) from the Silurian of Britain, Estonia, the Pechora Basin of the U.S.S.R. and North America bears closer similarities to *E. undatum* but it too can be distinguished by having slightly wider spacing of laminae (10-12 in 2mm) and less conspicuous pillars (Nestor, 1964).

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EXPLANATION OF PLATES

PLATE 1.

Figs. 1-2. *Clathrodictyon idense* sp. nov.; holotype (UTGD 58125) from Ida Bay, X10. 1, longitudinal section. 2, tangential section.

Figs. 3-6. *Clathrodictyon molense* sp. nov.; holotype (UTGD 94622) from locality on roadside leading to quarry, west of The Den, Mole Creek. 3-4, longitudinal sections X10. 5, logitudinal sections showing detail of part of fig. 4, X20. 6, tangential section, X10.

PLATE 2.

Figs. 1-5 *Clathrodictyon plicatum* sp. nov. X10. 1, vertical section of paratype UTGD 94623. 2, vertical section of paratype UTGD 94631, showing latilaminae with closed spaced laminae. Note possible foreign body around which new laminae are draped in the upper part of coenosteum. 3, vertical section of holotype UTGD 94626. Note dissepiments in areas of coenosteum showing widely spaced laminae. 4, tangential section of holotype UTGD 94626. 5, vertical-oblique section of paratype UTGD 94631 exhibiting in axial part of 'bulge' a *Plexodictyon*-like structure. Figs. 1, 3 and 4 are from an area just off the road near quarry west of The Den, and Figs. 2 and 5, from The Den, Mole Creek area.

PLATE 3.

All figures X10.

Figs. 1-3 *Ecclimadictyon undatum* sp. nov. 1-2, vertical and tangential sections of holotype UTGD 94636, off road near quarry, west of The Den, Mole Creek area. 3, vertical section of paratype UTGD 94638 south-east of Westfield Rd., Florentine Valley area. Note patches of coenosteum are destroyed or silicified.

Figs. 4-5 *Clathrodictyon* sp., vertical and tangential sections of UTGD 94633 from The Den, Mole Creek area. Note latilaminae and tabulated caunopore tubes.

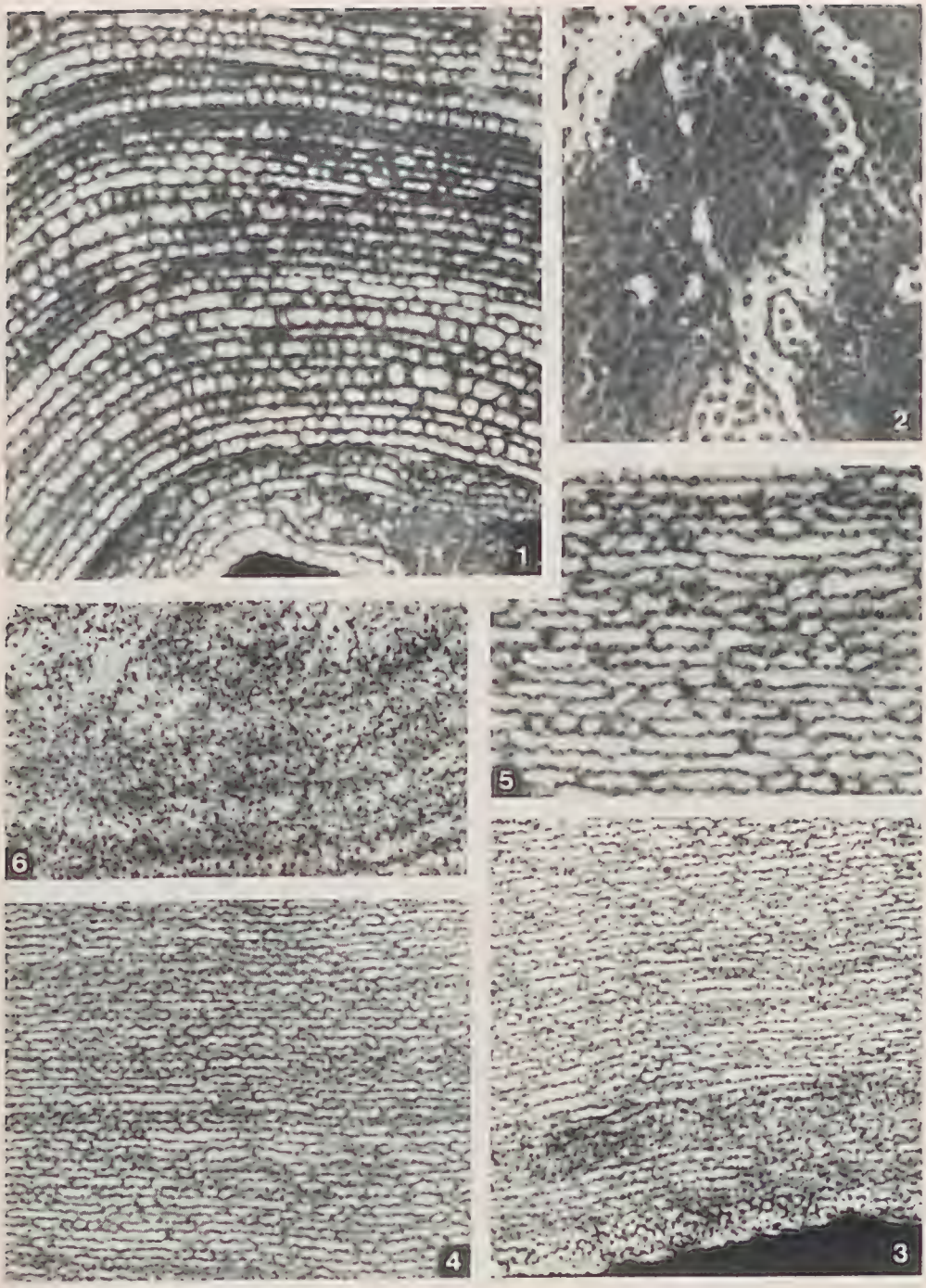
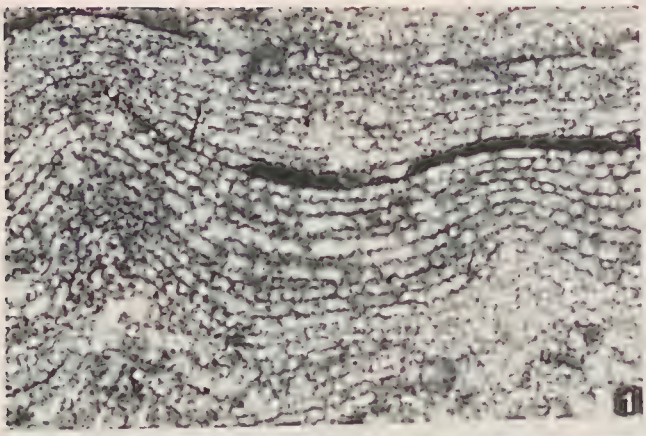
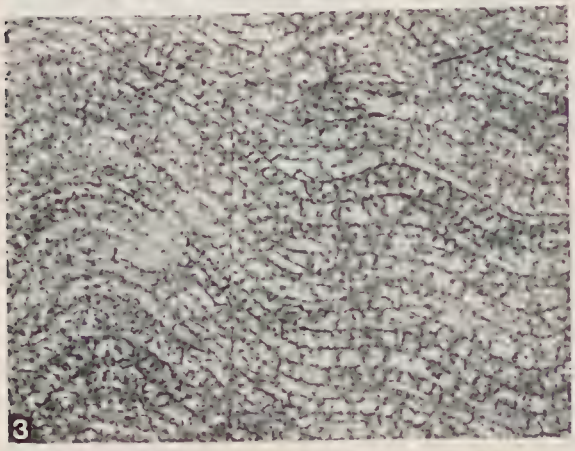


PLATE 1





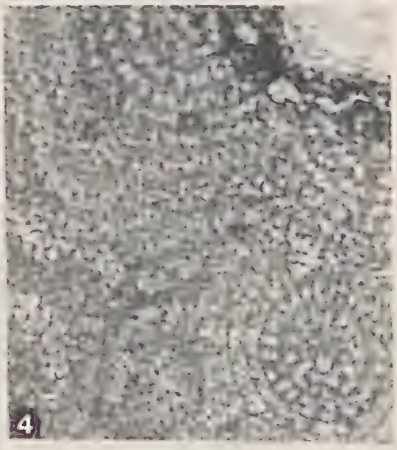
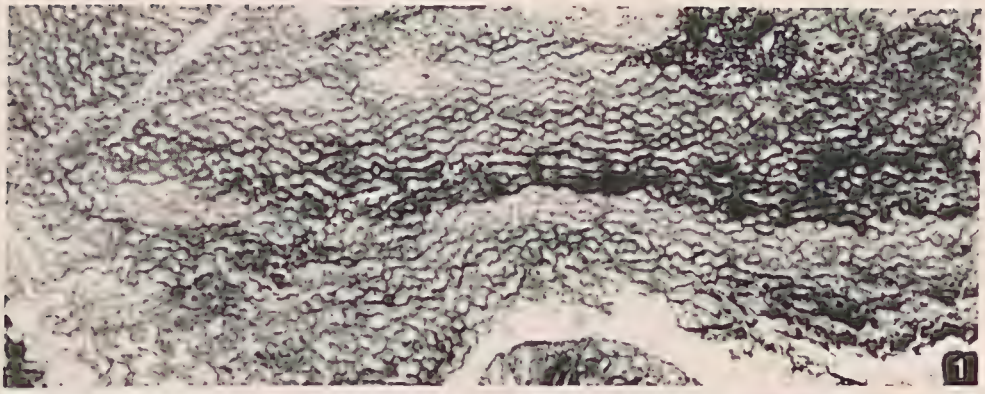
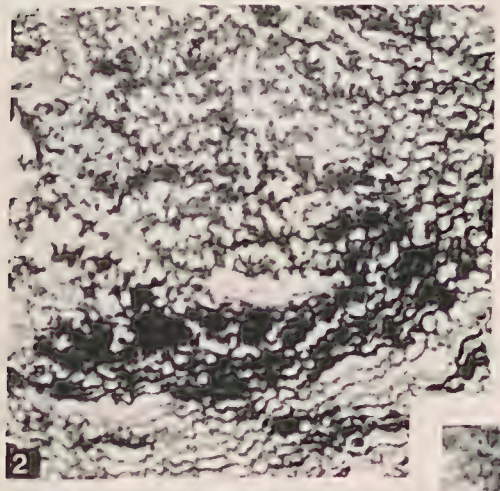
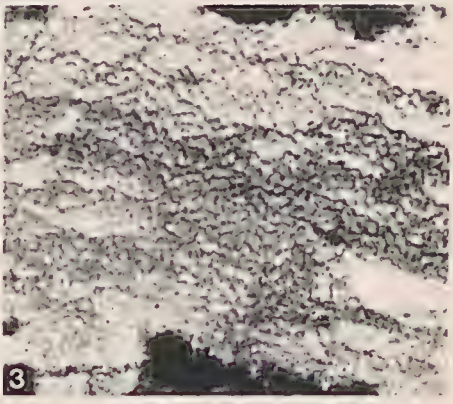


PLATE 2







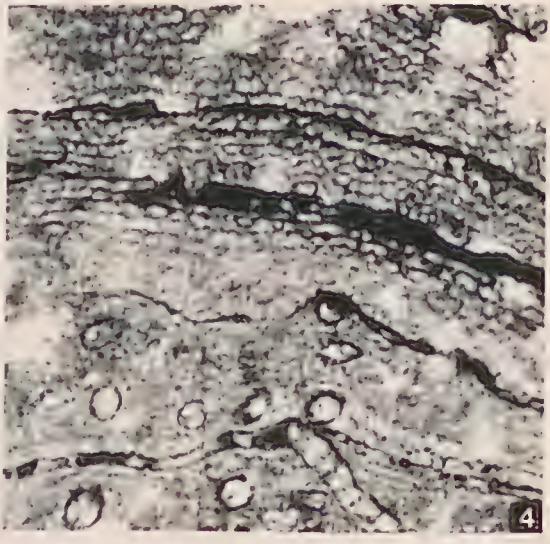


PLATE 3

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(ms. received 26.9.1975)

ADDITIONS TO THE LICHEN FLORA OF TASMANIA II

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ABSTRACT

New lichen records for Tasmania from recent collections (31), collections of W.A. Weymouth (39) and publications (31) are made. The total number of lichen species in Tasmania is estimated to be 460. Numerical comparisons with other areas are made and Victoria is shown to have the greatest floral affinity with Tasmania.

INTRODUCTION

The lichen flora of Tasmania has previously been extended (Bratt and Cashin 1975) by 35 taxa from that published by Wetmore (1963) as 521 taxa. The present work gives a further extension of the Tasmanian records from three sources viz. -

(a) 31 taxa collected by the present authors, details of which are given in Table 1.

(b) 39 taxa collected by W.A. Weymouth in the period 1891 - 1910 which are housed at the Herbarium of the University of Tasmania. Details of taxa, other than those already mentioned by Wetmore are listed in Table 2.

(c) 31 taxa recorded in recent literature or publications overlooked by Wetmore the details of which are set out in Table 3.

Although Wetmore lists 521 taxa the present authors have estimated that by taking synonyms, misidentification, and trivial indistinguishable forms into account there are 324 valid taxa in the list. Hence it is presently estimated there are 460 taxa validly recorded in Tasmania, a number revisable downwards as nomenclatural problems are examined and upwards as a large number of crustose collections are identified. Numerical comparisons of floras via species density (Wetmore 1967) and Sörenson coefficients (Sheard 1962) have been made and are listed in Table 4.

The numerical comparisons are crude and are made cruder by difficulties in nomenclature and the poor recording in some areas. It is expected that comparisons between Tasmania and other Australian States will be improved when unpublished work by various Australian authors becomes available.

Some interesting points emerge from the data of Table 4 and these are summarised below.

(a) For regions with areas of a similar magnitude (e.g. Tasmania, Victoria, New Zealand and Tenessee) the species density is also of similar magnitude. Since the N.Z. lichen flora is reasonably well established it is suggested that the closeness of the species density values for New Zealand and Tasmania indicates that a large proportion of the Tasmanian species have been recorded. The low species density values for regions such as Queensland which has been fairly well investigated (Shirley 1888, 1889) may be due to the relatively small climatic diversity of such a large region.

(b) The Sörenson coefficients show as expected that the closest geographical areas, Victoria and New South Wales have the closest floral affinities with Tasmania. The rather strong resemblance between Tasmanian and New Zealand floras is also apparent.

(c) The rather high value of the Sörenson coefficient for Tasmania and Tennessee

probably illustrates that in preliminary compilations of floras there are a large number of ubiquitous lichen species.
(d) The relatively high Sörenson coefficients for Victoria and Queensland compared with other Australian States may not result from climatological relationships but may reflect the extensive work in these States and Tasmania by Wilson (1892) and Shirley (1888, 1889) leading to marked increases in the number of species in common.

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TABLE 1

NEW LICHEN RECORDS FOR TASMANIA (RECENT COLLECTIONS)

Lichen	No. of Separate Collections	Altitude Range metres	Substrate	Typical Habitat	Typical Collection Locality (Division of State in Brackets)
Acarospora schleicheri (Ach.) Mass.	5	30-460	sandstone, dolerite, granite	exposed rock outcrops coastal & inland	Spring Bay (E)
Arthonia cinnabarina (D.C.) Wallr.	1	600	*Melaleuca* sp.	*Melaleuca* groves	Lemonthyme (N.W.)
Aspicilia alpina (Sommerf.) Arn.	3	760-1250	dolerite, quartzite	exposed mountain ridges	Mt. Snowy (S)
Buellia pulchella Tuckerm.	11	760-1280	dolerite & moss	crevices in mountain boulders	Mt. Wellington (S)
Cladonia bacillaris (Ach.) Nyl.	5	400-1070	doleritic soil	mountain moorland	Moors nr. Great Lake (C)
Cladonia didyma (Fee') Vain.	1	60	button grass soil	button grass plains	Picton Plains (S.W.)
Cladonia ecmocyna (Ach.) Nyl.	1	1520	doleritic soil	exposed mountain outcrops	Mt. Ossa (C)
Cladonia subdigitata Vain.	31	60-1520	soil and rotting logs	sheltered forests & open moorlands	Mt. Mawson (C)
Coccotrema curcubitula Müll. Arg.	24	60-1280	soil and rotting logs	mountain boulders lowland moors	Cradle Plateau (N.W.)
Ephebe fruticosa Henssen	18	120-1200	dolerite	mountain boulders or rocks in streams	Devil's Gullet (N.W.)
Lecanora badia (Hoffm.) Ach.	1	900	quartzite	mountain boulders	Mt. Arrowsmith (W)
Lecanora blanda Nyl.	12	60-1040	dead wood and rocks	rocks and logs in light timber	Mt. Faulkner (S)
Lecanora cenisea Ach.	9	2- 180	dolerite, sandstone limestone, soil	maritime rocks	Spring Beach (E)
Lecidea dicksonii (J.F. Gmel.) Ach.	5	460-1520	dolerite	mountain boulders	Ben Lomond (N.E.)
Lecidea friesii Ach. in Libjelbl.	9	460-1220	burnt and dead *Eucalyptus* logs	burnt areas on mountain sides	Sth. Wellington Gap (S)
Menegazzia aeneofusca (Müll. Arg.) Sant.	20	460-1340	dolerite, granite quartzite	mountain boulders	Mt. Marion (S)
Menegazzia globulifera Sant.	11	670-1220	*Nothofagus*, *Richea*, *Telopea* Sp.	*Nothofagus* forests	Mt. Rufus (C)
Neuropogon ciliatus v. *capillaris* Galloway	4	1040-1220	dolerite	rocky outcrops on mountain ridges.	Lake Augusta (C)

TABLE 1

(Continued)

NEW LICHEN RECORDS FOR TASMANIA (RECENT COLLECTIONS)

Lichen	No. of Separate Collections	Altitude Range metres	Substrate	Typical Habitat	Typical Collection Locality (Division of State in Brackets)
Parmelia cheelii Gyel.	12	80-1220	granite, quartzite sandstone, dolerite	open mountain slopes	Mt. Amos (E)
Parmelia dichotoma Müll. Arg.	9	3- 550	granite, sandstone dolerite	dry sclerophyll areas	Mt. Amos (E)
Parmelia furcata Müll. Arg.	9	3- 600	granite, sandstone dolerite	dry sclerophyll areas	Lake Leake (C)
Parmelia scabrosa Tayl.	15	3-1160	dolerite, basalt sandstone, granite	open forests	Table Mt. (C)
Parmelia subcaperata Kremp.	15	6- 600	dolerite, sandstone granite	rocks in light *Eucalyptus* forest	Grass Tree Hill (S)
Parmelia taractica Tayl.	14	15- 460	mudstone, sandstone dolerite, granite soil	rocks in light *Eucalyptus* forest	East Risdon (S)
Placopsis trachyderma v. clavifera (M. Lamb.) James	4	300- 600	mine spill	recently exposed rock	Mt. Bischoff (N.W.)
Pseudocyphellaria amphisticta (Knight)	9	300-1040	*Melaleuca* and *Nothofagus* sp.	damp sheltered forests	Mt. Picton (S.W.)
Pseudocyphellaria australiensis H. Magn.	66	6- 900	dolerite, sandstone granite, quartzite	rocks in light *Eucalyptus* forest	Waterfall Bay (S)
Pseudocyphellaria intricata (Del.) Vain.	5	180- 900	*Acacia* and *Nothofagus* Sp.	damp sheltered forest	Western Bluff (N.W.)
Psoroma contextum Stirt.	21	300-1160	*Melaleuca* Sp. dead wood	damp sheltered	Wedge River (S.W.)
Psoroma paleaceum (Fr.) Nyl.	19	460-1220	soil and dead wood	mountain moors and light forests	Lake Dobson (C)
Siphula fragilis (Hook. *et* Tayl.) Murray in ed.	29	800-1620	doleritic soil, moss cushion plants	mountain moors	Cradle Plateau (C)

Notes on Table 1. - Divisions of State are - E = East; C = Central; S = South; N.W. = North West; S.W. = South West; W = West.

TABLE 2

NEW TASMANIAN LICHEN RECORDS FROM WEYMOUTH COLLECTIONS

Lichen	Collection No. (1)	Determination by	Collection Locality
Arthonia complanata Fee	723	2	Wellard Ck, Tasman Pen.
Arthonia propinqua Nyl.	730	"	Wellard Ck, Tasman Pen.
Arthonia radiata (Pers.) Ach.	643	"	"Carnarvon", Tasman Pen.
Arthopyrenia gemellipara (Kn. Müll. Arg.	834	3	Kermandie, nr. Geeveston
Arthothelium infuscatum Müll. Arg.	967	"	Strickland Ave, nr. Hobart
Arthothelium interveniens (Nyl.) Zahlbr.	968	"	Strickland Ave, nr. Hobart
Bacidia atrogrisea (De. apud Hepp.) Korb.	853	"	Strickland Ave, nr. Hobart
Bacidia buchani (Kn.) Hellb.	886	2	McRobies Gulley, nr. Hobart
Bacidia millegrana (Tayl.) Zahlbr.	286	"	Millhouse's Falls,Huon Rd,nr.Hobt.
Blastenia endochromoides (Nyl.) Müll. Arg.	106	"	St.Crispin's Well,Mt. Wellington
Catillaria melaclinea (Nyl.) Zahlbr.	286(C)	"	Millhouse's Falls,Huon Rd.nr.Hobt.
Graphina platycarpa Zahlbr.	606	"	Wellard Ck, Tasman Pen.
Graphis scripta Ach.	908	3	Catamaran
Lecanora atra (Huds.) Ach.	162	2	Longley
Lecanora cancriformis (Hoffm.) Vain.	309	"	Guy Fawke's Rivulet, nr. Hobart
Lecanora glaucoflavens Müll. Arg.	264	"	"Springfield", nr. Johnny's Ck.
Lecidea contigua (Hoffm.) Fries	340	"	Brisbane St., Hobart
Lecidea melancheima Tuck.	D.	"	Hobart Rivulet, Hobart
Lecidea leptoloma Müll. Arg.	729	"	Wellard Ck, Tasman Pen.
Lecidea pruinosula Müll. Arg.	674	"	Watchorn's Hill, nr. Hobart
Leptogium burgessii (Linn. apud Mum.) Mont. apud Webb	960	3	St. Patrick's Head
Leptogium molaccunum Vain.	957	"	Recherche Bay
Opegrapha atra Pers.	H.	?	"Carnarvon", Tasman Pen.
Opegrapha varia Pers.	764	3	"Carnarvon", Tasman Pen.
Opegrapha vulgata (Ach.) Ach.	685	"	"Carnarvon", Tasman Pen.
Parmelia concolor Sprgl.	70	"	Hobart
Parmelia prolixa v. subprolixa (Kremp.) Zahlbr.	784	4	Sugar Loaf Hill, nr. Lindisfarne
Parmentaria pyrenastroides (Kn.) Müll. Arg.	934	3	St. Mary's Pass
Pertusaria alpina Hepp. apud Ahles	953	"	Lenah Valley
Pertusaria cupularis Kn.	831	"	nr. Geeveston
Pertusaria laevis Kn.	945	"	Huon Valley

TABLE 2

(Continued)

NEW TASMANIAN LICHEN RECORDS FROM WEYMOUTH COLLECTIONS

Lichen	Collection No. (1)	Determination by	Collection Locality
Pertusaria multipunctata (Turn.) Nyl.	928	3	Blue Tier
Pertusaria nitidula Müll. Arg.	862	"	Strickland Ave, nr. Hobart
Phlyctella sordida (Kn.) Müll. Arg.	969	"	Strickland Ave, nr. Hobart
Phlyctella wilsonii Müll. Arg.	169	2	Guy Fawke's Rivulet, nr. Hobart
Pyrenula mamillana (Ach.) Trevis	707	"	Newmans Ck. Tasman Pen.
Pyrenula nitida f.elaeodes (Leight.) A.L. Sm.	708	3	Strickland Ave, nr. Hobart
Ramalina pollinaria v. rupestris Flk. apud Schaer.	897	3	Ramsgate
Thelotrema decorticans Müll. Arg.	725	2	Wellard Ck. Tasman Pen.

Notes on Table 2. (1) Collection numbers and letters used by W.A. Weymouth
Identifications by (2) F.R.M. Wilson
(3) R. Paulson
(4) A. Jatta

TABLE 3

NEW TASMANIAN LICHEN RECORDS FROM PUBLICATIONS

Lichen	Reference
Agyrophora subglabra (Nyl.) Llano	Blackman et al.1974
Anzia wilsonii Raes.	Bratt et al. 1976
Candellariella vitellina (Nyl.) A.L. Sm.	Cribb 1954[2]
Catillaria rimosa (Müll. Arg.) Zahlbr.	Cribb 1954[2]
Cetraria scutata (Wulf.) Poetsch	Weber 1975
Cladia fuliginosa R. Filson.	Filson 1970
Cladia sullivanii (Müll. Arg.) W. Martin	Martin 1965(b)
Cladonia "delicatula"[1]	Sutton 1928[3]
Cladonia "leptophylla"[1]	Sutton 1928[3]
Collema coccophorum Tuck.	Degelius 1974
Collema crispum (Huds.) Wigg	Degelius 1974
Collema durietzii Degel.	Degelius 1974
Collema glaucophthalmum v. glaucophtalmum Degel.	Degelius 1974
Collema laeve v senecionis (F. Wils.) Degel	Degelius 1974
Collema subconveniens Nyl.	Degelius 1974
Collema subflaccidum Degel.	Degelius 1974
Gymnoderma melacarpum Yoshimura	Yoshimura 1973
Lichina tasmanica Henssen.	Henssen 1969
Ochrolechia parella (L.) Mass.	Cribb 1954
Parmelia erumpens Kurok.	Kurokawa 1969
Parmelia notata Kurok.	Kurokawa et al. 1971
Ramalina geniculata v. compacta Müll. Arg.	Weber 1971
Ramalodium succulentum Nyl. Ex. Cromb.	Weber 1975
Rhizocarpon geographicum (L.) D.C.	Sutton 1928
Teloschistes spinosus (Hook. f. et Tayl.) J. Murray.	Filson 1969
Teloschistes spinosus f. subteres Filson.	Filson 1969

TABLE 3
(Continued)

NEW TASMANIAN LICHEN RECORDS FROM PUBLICATIONS

Lichen	Reference
Umbilicaria polyphylla (L.) Baumg.	Blackman et al 1974
Usnea capillacea Motyka	Weber 1969 & 1975
Usnea flexilis Stirt.	Weber 1969
Verrucaria microsporoides Nyl.	Cribb 1954
Xanthoria ectanea (Ach.) Raes ex Filson.	Filson 1969

Notes on Table 3. (1) These epithets have not been traced to date

(2) Identification by P. Bibby

(3) Identifications probably by L. Rodway

TABLE 4

NUMERICAL COMPARISON OF FLORAS

Region	Lat. Range	Long. Range	Total Species	Reference	Area ha x 10^6	Species Density (1)	No. Common Species (2)	Sörenson Coefficient (3)
Tasmania	41°-44°S	145°-148°E	460	Present work	6.8	67.8	460	100
Victoria	34°-39°S	141°-150°E	647	Weber & Wetmore 1972	22.8	28.4	182	32.88
New South Wales (incl. A.C.T.)	29°-34°S	141°-154°E	373	Weber & Wetmore 1972	80.4	4.6	104	24.96
Queensland	11°-34°S	138°-154°E	1010	Weber & Wetmore 1972	173.7	5.8	122	16.59
Western Australia	14°-35°S	113°-129°E	124	Weber & Wetmore 1972	252.8	0.5	48	16.44
South Aust. (incl. N.T.)	12°-38°S	129°-141°E	51	Weber & Wetmore 1972	234.1	0.2	28	10.96
Australian Mainland	11°-39°S	113°-154°E	1915	Weber & Wetmore 1972	763.5	2.5	278	23.41
New Zealand (both islands)	35°-47°S	167°-179°E	1296	Martin, 1965, 1966, 1968	26.9	48.2	210	23.92
Iles Kerguelen	48.5^{o}-49.5^{o}S	69°-70.5^{o}E	118	Dodge 1948	0.7	181.5	6	2.08
Black Hills	43°-45°N	103°-105°W	404	Wetmore 1967	1.3	313.2	55	12.73
Tennessee	35°-36°N	82°- 90°W	463	Skorepa 1972	10.9	42.6	90	19.5

1. Species Density = number of species/10^6 hectare

2. No. of species in common with those in Tasmania

3. Sörenson Coefficient = $\frac{200 \times \text{number of species in common}}{\text{sp. in Area A + sp. in Area B}}$

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DISTURBED BEHAVIOUR AND MOON PHASES

by N.D. McGlashan, University of Tasmania

and T.R. Hay, Westwinds Home

(with two tables and two text-figures)

ABSTRACT

Data upon the behaviour of hyper-reactive male adolescents in care is reviewed against lunar phase to assess whether human bio-rhythmic patterns seem to be influenced by this form of extra-terrestrial cyclic change. Statistical tests suggest some correlation between attitude or behaviour patterns and days with the moon in the full phase.

INTRODUCTION

The existence of a temporal relationship between the behaviour of mentally disturbed persons and the phases of spatial arrangements between the earth and moon has been commonly believed through history (Oliver 1943) and gives rise to the etymology of the word "lunatic". Recent studies have tended to find contradictory evidence concerning the effect. In homicide a significant correlation has been demonstrated from one U.S. area (Lieber and Sherin 1972) but in psychiatric emergencies the effect has not been found (Bauer and Hornick 1968). It has always been difficult to prove or to disprove the hypothesis because comparable data of sufficient cases over long periods are generally needed. Most commonly the scientific conclusion has been merely that the figures have not supported any relationship of behaviour with moon phases. Conclusive denial of an effect is also lacking, and so the hypothesis lingers unproven in the limbo between superstition and old wives' tale.

The Tasmanian (State) Department of Social Welfare, assumes responsibility, as a result usually of court action for an ever-changing number of boys whose homes are unable for a wide variety of reasons to care for them. These boys include children of single parents or of grossly inadequate parents; some have been in minor police trouble, many are slow-learners or come to the department emotionally disturbed to a greater or lesser extent. It should be stressed that these boys are not criminals nor are they necessarily educationally sub-normal, though a few have received brain-damage at birth. Their existence reflects upon us all for they are more socially sinned against than sinners. In common these boys have a need for love, orderliness and security that most of them have never known.

One residential home for these boys is "Westwinds" in southern Tasmania. The home is staffed by eight permanent full time adults, receives boys from all over the State (viz. up to about 300 km distant) in the age group 7 to 16 and accommodates up to 20 boys at any one time. The regime deliberately sets out to provide a relaxed atmosphere, free of tension in either staff or boys. The boys may attend the local school, wander in the grounds and local countryside and they have opportunity for visits, holidays and day-trips away. In spite of these intentions, the boys make up a naturally volatile, emotional and moody group particularly easily affected by outside influences or changes in their life patterns. If lunar influence were felt in human affairs, these hyper-reactive boys would be expected to form a suitable test

situation for its recognition. Furthermore, with an all-male test group, hormonal and menstrual rhythms of attitudinal response could be ignored. The boys at "Westwinds" might thus provide evidence of external effects upon behaviour at a non-criminal level and of a less extreme kind than the serious violence of other studies. Formalised, the single tail null hypothesis would state that no significant behavioural worsening could be detected with periods of full moon.

DATA

Ranked information about the "behaviour" and the "attitude" of 18 boys resident at "Westwinds" was analysed for the period between March 1973 and June 1974 providing data coverage for nearly 12,000 boy/days.

"Attitude" was defined as the ability to reach acceptance of instruction, and "behaviour" as an ability to live with and adapt to events external to oneself. Records were based upon the confidential judgement of the duty staff member for the day concerned in complete absence of any idea upon his part of future use to test a lunar hypothesis. Indeed the recording system was instituted originally for the guidance of visiting psychiatrists in prescribing medication and gauging its effectiveness. Lunar phase was not recorded on the boys' records and was added retrospectively. No possibility existed of lunar phase prejudicing the rank of behaviour or attitude awarded.

ANALYSES

For each method of testing, "full moon-days" were defined as the three day period straddling full-moon to include the day before and day after.

(i) Attitude and Behaviour against Moon Phases

The total boy/days recorded for attitude were 6230, of which 1702 (27%) were shown as rating one of the two attitude ranks below norm. These were 1279 days at -1 rank and 423 days at -2. Of these 6230 days 617 were full moon days of which 412 (67%) recorded normal behaviour, 156 (25%) full moon days were at -1 level and 49 days (8%) at -2 level of attitude but these two ranks were combined for analysis. Chi-squared testing of these data shows a significant association in time ($p < 0.001$) between rank scores for sub-normal attitude and full moon days (See Table I). That is the proportion of days rated subnormal for attitude is significantly higher when the moon is full.

TABLE I

Boys' Attitude Rankings and Lunar Phase

	Normal	Sub-Normal
Full Moon days	412 (66.8%)	205 (33.2%)
Other days	4116 (73.3%)	1497 (26.7%)

χ^2 with Yates' Correction = 11.70 at 1 d.f. p .001

TABLE II

Boys' Behaviour Rankings and Lunar Phase

	Normal	Sub-Normal
Full Moon days	389 (69.7%)	169 (30.3%)
Other days	3709 (73.3%)	1349 (26.7%)

χ^2 with Yates' Correction = 3.15 at 1 d.f. $0.05 < p < 0.10$

An exactly similar analysis of behaviour rankings against moon phases is summarised in Table II. Whilst this set of data just fails to reach the significance level of $p = 0.05$ it is broadly corroborative of the finding in Table I.

(ii) Correlation of Behaviour and Attitude

As would be expected, the order of agreement of ranks of the eighteen boys, by percentage of days below norm, is extremely high ($p < 0.01$ on Spearman's Rho Test) between the two parameters of behaviour and attitude. The "good" boys are good on both parameters generally and the "bad" similarly. The point illustrates consistency in rank awarding practice by varying staff and to varying boys during the period studied.

When the "better" half of the group of 18 boys was removed, as suggested by Bauer and Hornick (1968), no significant relationship was found amongst the 9 "worse" boys between attitude rank and full moon days or between behaviour rank and full moon days. The difference between the "worse" and the "better" halves of the boys is slight; for example, the worse had only 3% more days ranked as below normal for attitude. It is clear that the fuller tabulations including all the boys are necessary to detect these slight differences.

(iii) Monthly Cycles of Attitude and Behaviour

As an alternative method of approach figs. 1 and 2 show the full daily variations of each parameter against the phase of the moon. The number of days recorded varied considerably (from 168 thirteenth days after new moon to 245 twenty-sixth days after new moon) because of irregular breaks in the record for holidays and other absences. All counts of days were therefore expressed in percentages to provide easy visual comparability.

For each graph, confidence limits at +2 and -2 standard deviations have been added, and in each case a trough in "normal" ranking must, of course, produce a peak in ranks less than normal, although not necessarily evenly in each of the sub-normal ranks.

Whilst normal attitude (top graph of fig. 1) is clearly achieved less often about the full moon, it is also less often reached about the twenty-second day. In neither case does the variation from the mean (72.8% of all days being normal) reach significant proportions. Conversely the apparent peaks of -1 rank of attitude and of -2 rank of attitude do not attain significance compared with their respective ±2 s.d. values depicted. Thus these daily variations could be the result of chance.

The graph concerned with behaviour (fig. 2) shows rather less consistency. For example, day 21 appears as a virtuous day with a peak of normal behaviour and low troughs of both -1 and -2 ranks below normal. Conversely day 26 has fewer normal and more sub-normal behaviour days. In each case, however, there is no temporal corroboration from consecutive days nor is there any suggestion of a group of days with a fixed pattern of behaviour occurring with regularity at any phase of the lunar month.

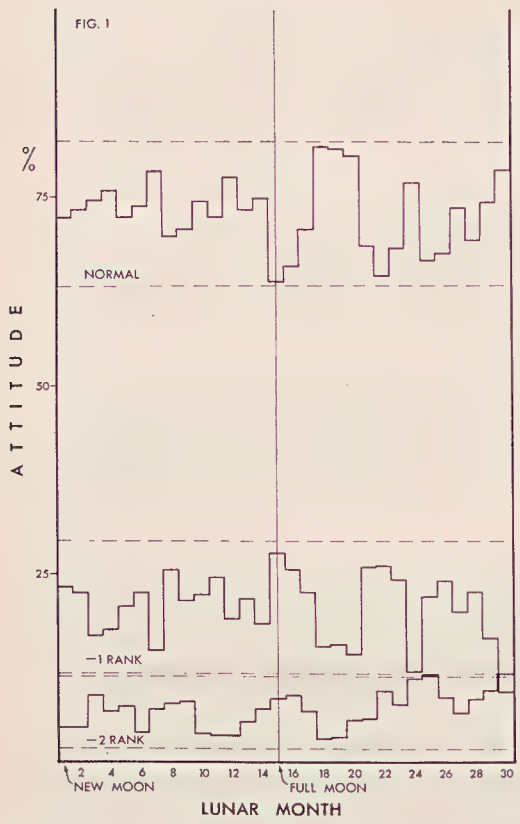

FIG. 1.- Attitude variation with lunar phase

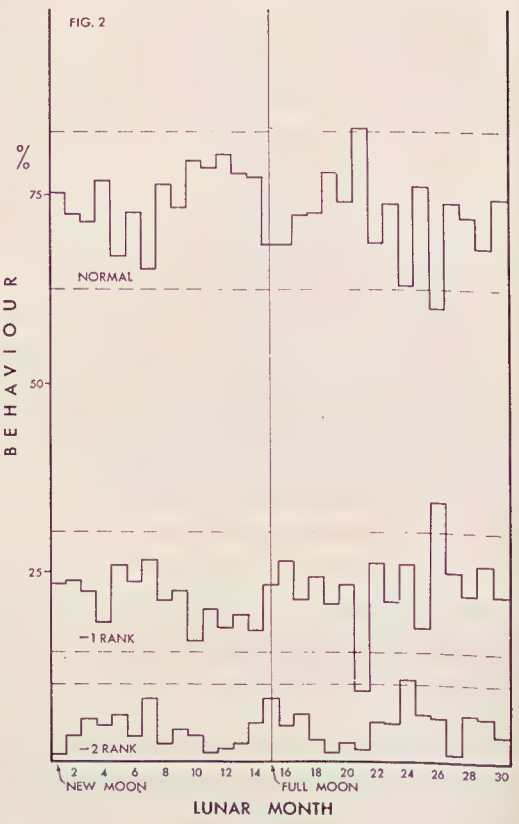

FIG. 2.- Behaviour variation with lunar phase

CONCLUSION

Only the first of these tests suggests that these boys' attitudes or behaviour patterns are affected on days with the moon in the full phase. The initial null hypothesis is tentatively rejected in that case. This disagrees basically with the failure of Shapiro *et al* (1970) to confirm any effect of lunar phase. There is, however, no apparent difference in the way that different groups of boys, grouped respectively by attitude and by behaviour, react to phases of the moon. The total number of boy/days examined (11,846 in Tables I and II), even when divided into two halves, would be expected to suffice to show a tendency to differ if such existed. The question of whether this lunar effect upon human biorhythm is induced by moonlight itself or alternatively by the moon's gravitational influence upon bodily tides (Oliver 1943) becomes relevant only once the effect itself is accepted.

ACKNOWLEDGEMENT

This study is reported with the kind consent of the Director, Tasmanian Department of Social Welfare.

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ALBINISM IN THE TASMANIAN DEVIL

By Eric R. Guiler
Department of Zoology, University of Tasmania

(with one plate)

ABSTRACT

An albino Tasmanian devil (*Sarcophilus harrisi* (Boitard)) has been captured near Bothwell, Tasmania. This is the first record of albinism in the Dasyuroidea.

TEXT

The Tasmanian devil, *Sarcophilus harrisi* (Boitard), usually has a general body colour of black, relieved in most individuals by white markings on the rump, chest and the lateral surface of the shoulders. The distribution of the white patches varies considerably, most devils having a white rump patch frequently combined with one or more of the other markings. In a small wild population the distribution and character of the marks is sufficiently characteristic to be used to identify individuals. Large white areas are very unusual and although a few devils may have large white rump patches this is most uncommon, the area of this mark usually being less than 12 sq.cm.

Melanic devils were reported by Fleay (1946) who found that "nearly all" of the 19 devils captured at Jane River (West Coast) were melanic although data collected by Guiler (unpub. obs.) shows that 5.6% of another West Coast population of 263 animals were all black.

However, colour phases other than melanic and the variations noted above have not been reported until the recent capture by Mr. J. O'Toole of an albino devil on Hunterston property, near Bothwell, Tasmania (Lat. 42°13'S.; Long. 146°50'E.). The animal, a fully grown male judged to be about 3-5 years old was white in colour, the only black being the rhinarium, the end of the snout as far posteriorly as the vibrissae, the mystacial vibrissae, and 3 small round spots, the largest being about 2 cm. diameter, on the fronto-nasal region. The ears, eyes and their surrounding areas all were pink.

The animal was rounded up by sheep dogs near a fowl house where it had been believed to have killed hens. The devil was photographed and released but has not been recaptured.

Albinism is known to occur in a number of marsupials, the brush possum, *Trichosurus vulpecula* (Kerr), and the rufous wallaby, *Wallabia rufogrisea* (Desmarest), frequently showing this colour in wild Tasmanian populations. However, albinism or a white colour phase have not been reported from either the Dasyuroidea or the Dasyuridae, the groups to which the Tasmanian devil is assigned, and this colour phase must be very rare in this group of the marsupials.

I am indebted to Mr. R. O'Toole, formerly Assistant Ranger, National Parks and Wildlife Service for this information and for the photographs taken by Mr. J. O'Toole. I also wish to thank the Director of the Service, Mr. P. Murrell for his co-operation. A colour photograph of the animal has been deposited in the Photographic Department of the University of Tasmania, File No. 74/11/89.

REFERENCE

Fleay, D., 1946: On the trail of the marsupial wolf. *Vict. Nat.*, 63, 129-35.

Albino *Sarcophilus harrisi* from Bothwell, Tasmania, May, 1974.

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(ms. received 5.1.1975)

OBSERVATIONS ON SOME TASMANIAN FISHES : PART XXII

by E.O.G. Scott,
Launceston

(with seven tables and one plate)

ABSTRACT

Three species, *Raja dentata* Klunzinger, 1872 (Rajidae), *Alabes parvulus* McCulloch, 1909 [1](Alabetidae), *Acanthistius serratus* (Cuvier, 1828) (Epinephelidae) are added to the local list; some observations are made on the material on which the two latter records are based. It is pointed out that while *Somniosus antarcticus* Whitley, 1939 (Somniosidae) does not appear in Australian, but is sometimes included in New Zealand, catalogues, the type locality, Macquarie Island, is formally part of a Tasmanian municipality.

A first record in Tasmanian waters of *Halsydrus maximus* (Gunner, 1765) (Halsydridae) in 1936 is supplemented by two records in January and March 1974; one specimen is figured.

General observations are made as follows. Echelidae, morphometric data, coloration in 20 specimens of *Muraenichthys ogilbyi* Fowler, 1908: Scorpidae, relative growth, development of color pattern in *Atypichthys strigatus* (Günther, 1860): Trichiuridae, Tasmanian material of *Lepidopus caudatas* (Euphrasen, 1788), status of *L. lex* Phillipps 1932, discounted: Soleidae, new locality record for *Zebrias fasciatus* (Macleay, 1882): Gobiescocidae, general review of the three Tasmanian species, *Creocele cardinalis* (Ramsay, 1882), *Aspasmogaster tasmaniensis* (Günther 1861), *Cochleoceps spatula* (Günther, 1861): Gobiidae, morphometric and other data on long series of *Arenigobius bifrenatus* (Kner, 1865) and *A. tamarensis* (Johnston, 1883): Scorpaenidae, juveniles, growth curve of *Gymnapistes marmoratus* (Cuvier, 1829): Aploactidae, *Aploactisoma milesii* (Richardson, 1850), general description, length-position relationships of spines and rays, subspecific status.

Keys are provided to Tasmanian representatives of the families Alabetidae, Epinephelidae.

INTRODUCTION

This paper follows the general plan of others in the series. Linear measurements are given, unless otherwise specified, in millimetres, the name of the unit commonly being omitted. The symbols *Ls Lt, TLs, TLt* denote standard length, total length, thousandths of standard length, thousandths of total length, respectively. Sample standard deviation is calculated with n degrees of freedom; derived statistics being computed from the value thus obtained. Registration numbers are those of the Queen Victoria Museum, Launceston. Certain other conventions are noted in earlier contributions.

[1] For earlier published record see NOTE ADDED IN PRESS on p. 217.

Family HALSYDRIDAE (olim CETORHINIDAE)

Genus *HALSYDRUS* Fleming, 1809

Halsydrus Fleming, 1809, *Scots Mag.*, p. 17. Haplotype, *H. pontoppidiani* Fleming
Squalus maximus Gunner.

Halsydrus maximus (Gunner, 1765)

(Plate 1)

Squalus maximus Gunner, 1765, *K. Norske Vidensk Selsk. Trondh*, p. 17.
Type locality: Trondhjem, Norway.

Synonymy

The basking shark appears in the general literature under upwards of a score of scientific names (Whitley 1939, p.241). Up to the early 1930's it was referred to by most Australasian authorities either as *Selache maxima* (genus *Selache* Cuvier, 1816), or (in later texts with increasing frequency) as *Cetorhinus maximus* (genus *Cetorhinus* Blainville, 1816): the latter name has continued in current use among a few local writers, and remains the preferred form of most overseas workers. Since, on the one hand, the proposed recognition by Barrett (1933) of a separate Australian species, *Tetroras maccoyi* (genus *Tetroras* Rafinesque, 1810), and, on the other hand, the statement by Whitley (1934) that the 'Sea Serpent' of Stronsay, Orkney Islands, on which Fleming's genus *Halsydrus* was based (remains in the Royal College of Surgeons' Museum, London) was later identified as a basking shark, the shark has appeared in most Australasian and a few extralimital sources under Barrett's name, or as *Halsydrus maccoyi*, or as *Halsydrus maximus*. Specimens from Australia have been treated by some ichthyologists as a separate subspecies (third trinomen *maccoyi*): other trinomial names have been suggested for examples from other areas. An extensive bibliography of the basking shark extending from the earliest times to about 1940 has been given by Bigelow & Schroeder (1948): this is supplemented by a list by Whitley (1967) of upwards of a hundred and fifty references, of which about a quarter are Australasian.

Australasian records

A series of Australasian records of the basking shark between 1883 and 1956 has been compiled by Whitley (1967, table 2): it comprises 3 reports from New South Wales, 5 from Victoria, 5 from South Australia, 1 from the Great Australian Bight, 1 from Tasmania, 12 from New Zealand. The greatest length recorded is 34 feet 3 inches (10.4 m), the least 8 feet (2.4 m). For the 17 examples for which the datum is available the length distribution, in feet, is:10 feet or less 4; 11-15 6; 16-20 2; 21-25 2; 26-30 1; 31-35 1; 36-40 1.

First Tasmanian record

In the latest (fifth) published catalogue of Tasmanian fishes (Lord 1927) an unnumbered entry, interpolated between items 19 and 20 reads: 'Cetorhinus maximus — Basking Shark. One record, Banis Bay, 1926. No account of this specimen was published in the *Papers and Proceedings* of the Royal Society of Tasmania, to which Lord had earlier contributed notices of additions to the local faunal list, and no additional information about it has been found. In response to an inquiry to the Tasmanian Museum Hobart, Mr A.P. Andrews, Curator of Vertebrates, who kindly made a search of the institution's records, has reported they include no reference to this shark.

The locality 'Banis Bay' cited in Lord's paper (and regularly repeated in derivative literature) is unknown to the writer, and the suggestion is advanced that it could quite probably represent a misprint for Barnes Bay, the name of a large well-known bay on the west coast of the northern half of Bruny Island, southern Tasmania (misprints in the paper are numerous). Mr E.W. Clennet, Secretary, the Nomenclature Board of Tasmania, informs me the Board has no record of the name Banis Bay, and expresses the opinion the entry indeed seems likely to be an error for Barnes Bay.

Second Tasmanian record

On 16 January 1974, through the good offices of Mr A.J. Harrison, Secretary, Fisheries Division Agricultural Department, the writer learnt that the caudal fin of a large shark was on display on the deck of a Japanese fishing vessel moored at a Hobart wharf. The next day a photograph of the fin, with a member of the ship's crew standing beside it, appeared in the Hobart *Mercury*, the caption noting the ship was the *Fukuichi Maru* No. 31, and the shark, said to have measured 'about 15 metres', was caught on 4 January in Japanese fishing grounds off Tasmania.

Later, at the writer's request, Mr A.K. Way, Southern Regional Inspector of Fisheries, was good enough to take and make available for examination two colour photographs of the fin: these showed no spots (such as might be expected in a fin of the other very large species, the Whale Shark — in any case, a highly unlikely visitor to our waters). (The Whale Shark has conventionally been known hitherto as *Rhincodon typicus* Smith, 1829. In a recent paper (Penrith 1972) evidence has been adduced to show it should probably be called *Rhiniodon typus* Smith, 1828).

Mr Way provided a sketch, with measurements, of the (somewhat mutilated) caudal fin, showing the length of the superior lobe (1.04 m), the length of the inferior lobe (0.93 m), the direct distance from the line, close to the level of the origin of the inferior lobe, along which the fin had been severed from the body to the angle of the junction of the lobes (0.70 m), and the direct distance between the tips of the lobes (0.16 m). Included among the measurements given by M'Coy (1885) of his specimen (the first formally recorded in Australia, type specimen of *Tetroras maccoyi* Barrett, 1933, *ex* Whitley & Phillipps MS) are: length of upper caudal lobe to pit at base 5 ft 7 in., length of lower caudal lobe to pit at base 4 ft 0 in., length from tip to tip of caudal fin 7 ft 0 in. These three dimensions exhibit tolerably constant ratios (1.21, 1.31, 1.33, respectively) to the corresponding dimensions recorded by Mr Way for the Tasmanian shark. As percentages of total length, M'Coy's values are 18%, 11%, 23%. With an assumed total length of 15 m (49 feet), the corresponding percentages for the *Fukuichi Maru* specimen are 9, 6, 11: however, the loosely stated 'about 15 metres' would clearly seem excessive, 36 feet being given by a number of writers as a probable maximum length, though estimates of 40-45 feet have been suggested. With an assumed length of 7.5 m (25 feet), the percentages would become 19, 12, 21, comparable with M'Coy's values. In the West Coast example noted below the distance between the tips of the lobes of the caudal (the only item available) was, on the measurements given, 20% of the length of the shark.

Third Tasmanian record

In their issues of Thursday 7 March the Burnie *Advocate* and the Hobart *Mercury* carried reports of a basking shark netted in Macquarie Harbour by Mr R.A. Larsson, Strahan. Mr Larsson has been good enough to fill in a questionnaire submitted to him: from the information supplied the following points may be noted here. The shark was found entangled in a net left overnight, during a change-over of nets, on Tuesday 5 March, on the off chance of catching school fish, about 4 miles (6-7 km) south of Sapphire Point in Macquarie Harbour. Its length (direct, not following curves) was 25 feet (7.6 m), and the distance between the tips of the caudal lobes was 5 feet (1.5 m). In reply to a question about colour, Mr Larsson noted it lacked spots or lines, and it was overall very dark, almost black, after having remained for some hours in the ore-contaminated water of the Harbour. It was a male. Other information supplied by Mr Larsson in answer to inquiries regarding features likely to be of value in identifying the specimen (including shape of head, size of gill slits, nature of teeth, presence of short keel on caudal peduncle) were fully consonant with its determination as a basking shark. Subsequent examination of three photographs (two here reproduced, pl. 1, figs a, b) leaves no doubt about the species.

The taking in Tasmanian waters, after a lapse of almost half a century, of two examples of *Halsydrus maximus* within the space of a few months has appeared to be worthy of record.

A

B

PLATE 1. *Halsydrus maximus* (Gunner, 1765); Strahan, March 1974; (a) anterior view, (b) postero-lateral view. Photographs by courtesy of the *Advocate*.

Family SOMNIOSIDAE

Genus *SOMNIOSUS* Le Sueur, 1818

Somniosus Le Sueur, 1818, *J. Acad. Nat. Sci. Philad.*, 1 (9), p.222. Haplotype, *S. brevipinnis* Le Sueur.

Somniosus antarcticus Whitley, 1939

Somniosus sp. Waite, 1916, *Australas. Antarct. Exped.*, 1911-1914, Sci. Rep. *(C)* 3 (1) 1,p.51, fig. 10.

Somniosus antarcticus Whitley, 1939, *Aust. Zool.*, 9 (3), p.242. Type locality : Macquarie Island.

Remarks

A sketch by a Mr Hamilton of a curious shark, 8 feet 2 inches (4.5 m) long found cast up on a beach on Macquarie Island in 1912 was published by Waite (1916), who referred it to *Somniosus*, otherwise represented only by three northern hemisphere species : parts of the animal were preserved and later Whitley (1939) provided a specific name.

An account of *Somniosus antarcticus* is included by Whitley in his general work on Australian fishes (1940, p.152, fig. 170), but in the 'Scheme of classification of the fishes and fish-like animals of Australia' therein the entry Family Somniosidae is followed immediately by the notation '(Sleepers — not Australian)'; the species occurs in Whitley's check-list for the New Zealand region (1968, p.11), but not in his name-list of fishes recorded from Australia (1964); not noted in Munro's Australian handbook (1956); included by Garrick (1960, p.595) in a key to the New Zealand Squaloidea; noted by Garrick & Schultz (1963, p.59) as being found at Macquarie Island 'south of Australia.'

Macquarie Island, about 31 by 2 km, is situated in the South Pacific in lat. 54.29S. long. 158.58E. The climate, flora and fauna are typically subantarctic (*Aust. Encycl.*, no date, 5, p.453). Politically, it is part of Tasmania, being included in Esperance, the southernmost municipality of the main island.

It would thus appear that if *Somniosus antarcticus* is to be included in the faunal list of any Australasian state or country, it should be Tasmania, not New Zealand.

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Family RAJIDAE

Genus *RAJA* Linné, 1758

Raja Linné, 1758, *Syst. Nat.*, ed. 10, p.231. Logotype, *Raja batis* Linné.

Raja dentata Klunzinger, 1872

Raja dentata Klunzinger, 1872, *Arch. Naturges.*, 38, p.46. Type locality: Port Phillip, Victoria.

Raja (Dentiraga) dentata. Whitley, 1940, THE FISHES OF AUST., Part 1, p.164, figs 31, 214.

History of species

In terms of primary references the history of *Raja dentata*, the third rajid described with an Australasian type locality, is brief. The species, our least known ray, was based on two females from Victoria by Klunzinger more than a century ago; seven years later (1879) he reported the male, noting differences in dentition and in some of the spines. The types, preserved in the Württembergische Naturaliensammlung, Stuttgart, were examined there by the late Gilbert Percy Whitley, whose recent death has deprived ichthyology of one of its most outstanding Australian workers, and the present writer of an ever-helpful colleague and valued friend. He recorded (1939) that they were labelled 'Port Phillip, Australien, v. Muller, 1869-1871, selected the larger individual as lectotype, gave a brief general description of the specimens and provided the first figure of the species (outline dorsal aspect, outline anterior portion of ventral surface, teeth, velum maxillare, buccal processes); noting in the same paper the existence in the Australian Museum of one other Melbourne specimen (Regd No. I.12050). Later, in his general survey of Australian and New Zealand elasmobranchs (1940), he proposed for *R. dentata* the subgenus *Dentiraja*. Six types of rajid egg cases - of which only one is definitely associated with its species - are shown (fig. 31) in that work; a black egg case, about 4.4 cm by 3.2 cm, with long horns and with woolly sides being labelled '*Raja dentata?*' All other notices of the species are derivative.

Raja dentata escaped notice in the first comprehensive synopsis of Australian fishes, Macleay's descriptive catalogue (1881,1882), but an account in translation was included in the supplement (1884, p.63). It appears in the systematic Victorian census of Lucas (1890, p.45), where, however, the entry is placed in parentheses, the author's convention for records based on a single specimen and for species of whose occurrence in Victorian waters there is some doubt; in his introduction Lucas suggests there is a probability some confusion may have occurred in regard to Klunzinger's material, some specimens described as coming from Hobson's Bay and Port Phillip perhaps being South Australian fish. The species was not noticed by Stead (1963) in his general work on Australian sharks and rays. A conventional entry appears in the Australian Check-list (McCulloch 1929), and a brief diagnosis, on the pattern of those for related species, was given in the Handbook (Munro 1956): the Handbook's fig. 110 is the outline sketch of the dorsal aspect by Whitley (1939, fig. 16), which here (as in Whitley 1940, fig. 214) has been blocked in with monochrome grey.

Tasmanian record

Raja dentata is here reported from Tasmania. Three females, *(b)* total length 320, disc width 230, *(c)* 335, 237, *(d)* 436, 304 were taken, in the course of an Apex Fishing Competition, in the estuary of the Tamar, northern Tasmania, on 16 February 1975 (Q.V.M. Reg. No. 1975/5/23). It was later found the collections of the Queen Victoria Museum already contained a smaller female, *(a)* 229, 160, caught in 1942 off the pier at Gravelly Beach, Tamar river (approximately 33 km from the sea), in 30-40 feet (9-12 m) of water (Miss Audrey Lee; Reg. No. 1942.27): the specimen was labelled *Raja tasmaniensis*.

Description, morphometric data[1] A detailed description of this little known ray, based on the Tasmanian material, accompanied by morphometric data and including a comparative study of disc form will, it is hoped, be presented in the next contribution in this series.

Family ALABETIDAE

The Check-list (McCulloch 1929) recognizes four species of Alabetidae [rendered Alabidae by, among others, Jordan (1923), Munro (1957), Scott (1962)], all referred to *Alabes* Cloquet, 1816, namely *(a) Cheilobranchus dorsalis* Richardson, 1895, *(b) Chilobranchus rufus* Macleay, 1881 (*Chilobranchus* Günther, 1870, emendation for *Cheilobrachus* Richardson, 1845), *(c) Cheilobranchus parvulus* McCulloch, 1909; *(d) Alabes cuvieri* Vaillant, 1905 *ex* Kaup MS, based on the type specimens in the British Museum upon which *Alabes* was formed; locality given as India and New Holland. The Handbook (Munro 1957) accepts only *(a)*, *(b)* and *(c)*, but *(d)* is retained in the name-list of Whitley (1964).

A. rufus, found in New South Wales, Victoria and South Australia, is abundant in this State (which is the type locality along with Port Jackson). *A. dorsalis*, reported in the Check-list as occurring in north-western Australia (type locality), Tasmania, South Australia (the last named locality queried in the Handbook; this species is not included by Scott (1962) in his catalogue for that State or by Scott *et al.* in a later version), appears in all published local lists — Johnston (1883, 1891), Lord (1923, 1927), Lord & Scott (1924) — but appears to be rare here: the first two examples seen by the writer were the subject of some observations in Part XX (1973b). *A. parvulus*, hitherto known only from New South Wales, is here reported from northern Tasmania — one more instance of a species being recorded from these two State only.

The subjoined key will serve to separate the three Tasmanian species; it supersedes an earlier key (1974b, p.175) to the two species then on our list.

KEY TO ALABETIDAE RECORDED FROM TASMANIA

1. Dorsal originating shortly behind head, nearer to snout tip than to vent. Anal originating shortly behind vent, by < 0.5 (about 0.05) head length. Colour pattern, if present, a median dorsal stripe; no transverse or vertical bars, no spots, no vertebral stripe. ..... *A. dorsalis*

   Dorsal originating well behind head, nearer to vent than to snout tip. Anal originating well behind vent, by $>$ 0.5 (about 0.9-2.7) head length. Colour pattern, if present, including some or all of these, transverse or vertical bars, spots, vertebral stripe; no median dorsal stripe. ... 2

2. Gill opening with on either side an ovoid lobe, its length one-third, or more, width of opening. Anal originating behind vent $<$ 2 (about 0.9-1.3) head length. Colour pattern, if present, 1-9 large spots on either side; no other markings. Size greater, total length to about 100 mm ..... *A. rufus*

   Gill opening without lateral lobes. Anal originating behind vent by $>$ 2 (about 2.5-2.7) head length. Colour pattern, if present, some or all of these bars and/or spots on back, on sides and ventral surface of head and trunk, vertebral stripe. Size less, total length to about 50 mm ..... *A. parvulus*

Approximate ranges given in parenthesis in the key are based on data for specimens noted in Part XX (*A. dorsalis* 2 individuals, *A. rufus* 5) and on examples here discussed (*A. parvulus* 2).

[1] For earlier published record see NOTE ADDED IN PRESS on p. 217.

Genus *ALABES* Cloquet, 1816

Albes Cloquet, 1816, *Dict. Sci. Nat.*, 1, suppl., 1816, p.99.
Ex Cuvier MS. Logotype, *A. cuvieri* Vaillant.

Alabes parvulus (McCulloch, 1909)

Cheilobranchus parvulus McCulloch, 1909, *Rec. Aust. Mus.*, 7 (4), p.316, fig. 18 (outline sketch). Type locality: rock pools near Sydney.

Alabes parvulus McCulloch, 1929, *Aust. Mus. Mem.*, 5 (1), p.62. *Id.* Whitley, 1929, *Rec. Aust. Mus.*, 17n(3), p.108, pl. 31, fig 7 (colour figure by McCulloch). *Id.* Munro, 1957, *Handbk Aust. Fish.*, 10, p.44, fig 311.

Tasmanian record

Mr R.H. Green, Curator of Zoology, Queen Victoria Museum, has drawn the writer's attention to a 15 mm colour transparency taken by him of an *Alabes* collected at Greens Beach, northern Tasmania, on 14 November 1966. This fish and another taken on the same occasion prove to be the first examples of *A. parvulus* recorded from this State (Q.V.M. Reg. No. 1972/5/402.).[1]

Dimensions

Total length 37.5, 45.3. Other dimensions as millesimals of total length follow (absolute dimensions, mm, in parentheses). Length to dorsal origin 333, 307 (12.5, 13.9), to anal origin 653, 618 (24.5, 28.0), to vent (middle) 347, 325 (13.0, 14.7). Head 125, 110 (4.5, 5.0), snout 293, 221 (1.1, 1.0), eye 267, 199 (1.0, 0.9), interorbital 133, 135 (0.5, 0.7). Depth at vent 104, 66 (3.9, 3.0), immediately behind vent 80, 64 (3.0, 2.9); greatest depth of head 77, 42 (2.9, 2.2); maximum depth 112, 77 (4.2, 3.5); corresponding measurements of width 53, 33 (2.0, 1.5), 51, 29 (1.9, 1.3), 56, 42 (2.1, 1.9), 75, 62 (2.8, 2.8).

Comparison of body ratios

A comparative schedule of some relevant body ratios as found in *A. parvulus*, *A. dorsalis*, *A. rufus* as represented by our material is set out in table 1. Though the samples are small and obviously cannot be expected to provide critical differentiae in cases where values are not markedly different, some trenchant distinctions are provided by several ratios. Head in length to dorsal origin and head in dorsal origin -vent interval conveniently distinguish *A. dorsalis* from the other species, while head, or trunk, in anal origin-vent interval sorts out all three species.

Attention may be drawn to the value (3) of the ratio head in trunk in *A. rufus* as given in the Handbook (Munro 1957, p.44) and as found in our material (2.0-2.6, $\bar{x}$ 2.31 ± 0.074) : Waite (1906, p.195) recorded 2.3, and approximately the same value is derivable from his illustration (pl.36, fig. 1), a drawing by McCulloch.

Good agreement obtains between McCulloch's values for the metrical items noted in the original description of *A. parvulus* and ours. Head nearly one-ninth of total length (our specimens 0.12, 0.11), head in distance between gill opening and vent 1.8 (2.0, 1.8), head equal to (1.1, 1.4) height of body, length to vent in rest of length 1.7-2 (1.9, 2.1), eye one-fourth (0.22, 0.18) head, snout longer than (1.1, 1.1) eye.

Other features

Jaws equal anteriorly in smaller individual, upper projecting somewhat in larger; maxillary to just short of eye; snout spatulate, tip rounded, moderately acute (less obtuse than in *A. rufus*); interorbital 0.5, 0.7 eye; anterior nostril tubular, in advance of eye by about half an eye diameter, at about ten o'clock (left side viewed); posterior nostril closer to orbit at about nine o'clock; gill opening small simple crescentic aperture, without lateral lobes.

[1] For earlier published record see NOTE ADDED IN PRESS on p. 217.

Coloration

As seen in Mr Green's colour transparency the fish is tolerably similar in overall colour and in colour pattern to the living specimen from Coogee Baths, near Sydney, as represented in McCulloch's painting made available by Whitley (1929b), p. 21, fig. 4). However, after preservation most of the original colours have disappeared.

Larger specimen with trunk and tail mostly pale yellowish brown becoming somewhat amber and/or golden posteriorly. Except for hinder part of operculum, which is almost concolorous with trunk, head more yellowish, particularly lips, chin, ventral surface of branchial basket; optic lobes and diencephalon, visible through skull wall, deep cream; faint remains of upwards of a dozen well-rounded spots on either side of branchial basket; some variations in tone along middorsal line, apparently representing remnants of a colour pattern. Fins pale yellowish; no markings retained. Smaller specimen much like larger; dorsum of head darker, more brownish; optic lobes and diencephalon not visible, but front part of medulla oblongata apparent, somewhat lighter than adjacent region; two elliptical straw-coloured areas (olfactory lobes visible through skull?) on dorsum immediately in front of eyes.

TABLE 1

Alabes parvulus (McCulloch, 1909), *A. dorsalis* (Richardson, 1845), *A. rufus* (Macleay, 1881). Some body ratios of 2,2,5 individuals: mean values, with individual values in parenthesis.

	A. parvulus	*A. dorsalis*	*A. rufus*
1.	8.7 (8.3, 9.1)	8.5 (8.8, 8.3)	8.8 (8.6, 9.3, 8.4, 8.9, 8.9)
2.	1.9 (1.9, 1.9)	2.3 (2.4, 2.2)	2.3 (2.3, 2.3, 2.3, 2.0, 2.6)
3.	2.8 (2.8, 2.8)	1.2 (1.2, 1.2)	2.9 (2.9, 3.0, 3.1, 2.7, 3.3)
4.	0.14 (0.11, 0.16)	2.1 (2.2, 2.0)	0.31 (0.43, 0.30, 0.27, 0.34, 0.22)
5.	2.6 (2.6, 2.7)	0.034 (0.035, 0.033)	1.1 (1.29), 1.21, 0.93, 1.24, 0.89)
6.	0.32 (0.33, 0.31)	0.14 (0.14, 0.14)	0.35 (0.33, 0.33, 0.37, 0.33, 0.38)
7.	3.0 (2.9, 3.1)	2.6 (2.6, 2.6)	2.6 (2.6, 2.8, 2.5, 2.7, 2.5)
8.	0.64 (0.65, 0.62)	0.26 (0.26, 0.26)	0.51 (0.53, 0.49, 0.51, 0.53, 0.50)
9.	0.71 (0.59, 0.82)	0.93 (0.92, 0.93)	0.14 (0.19, 0.13, 0.11, 0.17, 0.09)
10.	1.4 (1.4, 1.4)	0.015 (0.015, 0.015)	0.49 (0.56, 0.52, 0.40, 0.61, 0.35)
11.	10.7 (8.5, 12.9)	8.9 (9.2, 8.7)	9.3 (10.0, 9.1, 8.4, 9.0, 9.9)

RATIO

1. Head in total length
2. Head in trunk
3. Head in length to dorsal origin
4. Head in dorsal origin-vent interval
5. Head in anal origin-vent interval
6. Length to dorsal origin in total length
7. Length to vent in total length
8. Length to anal origin in total length
9. Trunk in dorsal origin-vent interval
10. Trunk in anal origin-vent interval
11. Maximum depth in total length

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Family ECHELIDAE

Genus *MURAENICHTHYS* Bleeker, 1853

Muraenichthys Bleeker, 1853, *Natuurk Tijdschr. Ned.-Ind.*, 4, p.505. Orthotype, *Muraenichthys gymnopterus* Bleeker (designated 1864).

Muraenichthys ogilbyi Fowler, 1908

Muraenichthys ogilbyi Fowler, 1908, *Proc. Acad. Sci. Philad.*, 59, 3 (1907), p.423, fig. 3. Type locality: Victoria.

Date of genus

The genus *Muraenichthys* is commonly attributed in Australian and New Zealand texts – including the present studies (1953,1961,1963,1965,1974a) – to Bleeker, 1864, *Nat. Tijdschr. Dierk.*, 11, p.117. The reference given above, adopted by, e.g., Schultz (1953), is that listed in Neave (1940).

History of species

Fowler's species was based on one specimen included in a small collection of fishes from Victoria. A Tasmanian example, length without caudal fin 238, collected at Green's Beach, northern Tasmania in January 1969, providing probably the first non-derivative notice of the species since the description of the holotype, was made the subject of fairly detailed observations in Part XIX (1974 a). A fine series of 20 specimens, netted by Mr R.H. Green, Queen Victoria Museum, at the same locality on 19 and 26 January 1975 (Q.V.M. Reg. No. 1975/5/213) provides valuable morphometric data over an *Lt* range of 254.0-489.1.

Dimensions

Range, arithmetic mean, standard deviation and coefficient of variation, together with number of individuals lying within $\bar{x}$ and s (normal curve, 14) for *Lt* (mm) and for a number of dimensions expressed as thousandths of *Lt* (*Tlt*) are set out in table 2.

Proportions

Table 3 presents a similar set of statistics for a series of body ratios, including, for purpose of comparison, those recorded (table 1) in Part XXI (1975) for the holotype and the first (1969) Tasmanian example of the present species, a series of 8 Tasmanian examples of *M. breviceps* Günther, 1876, and the holotype of *M. lingowenah* Scott, 1975. It includes also the Schmidt index, S ($S = \frac{a-d}{t} \times 100$), where a = length to vent, d =length to dorsal origin, t = total length) : this criterion was introduced by E.J. Schmidt in his worldwide investigations on the Anguillidae (*e.g.*,1928); it was given its nominal designation in his honor in Part VI (1953, p.142) of the present series. Comparison of the two tables shows : for all listed proportions, values of the two earlier specimens of *M. ogilbyi* fall within the range of those of the present material, with the sole exception of *S.* for the 1969 individual (18.7,*cf.* 18.9–22.6), this transgression beyond the present lower extreme being, however, in accord with probable prediction, in view of the smaller size of that individual and the positive correlation of *S* with *Lt;* all values for *M. lingowenah* continue to lie outside those for *M. ogilbyi;* overlaps between joint values for the two examples of *M. ogilbyi* and the range of the eight examples of *M. breviceps* found in the earlier table are confirmed, the range of common magnitude naturally being in some instances increased with the inclusion of the data for the larger sample of the present species.

Relative growth

Significant positive correlation of body element as a permillage of total length with total length occurs in the following cases: depth at vent, $r = + 0.453$ ($z = 0.500$), $t = 2.155$*; depth at middle of tail, $r = + 0.707$ ($z = 0.882$), $t = 4.247$**.

Significant negative correlation obtains in maximum depth of body, $r = -0.452$ ($z = 0.487$), $t = 2.150$*; maximum depth of branchial basket, $r = -0.522$ ($z = 0.579$), $t = 2.597$*; length of maxilla, $r = -0.735$ ($z = 0.940$), $t = 4.850$**.

For the full sample of 20 the correlation of Schmidt's index with *Lt* is $r = +0.337$ ($z = 0.351$), $t = 1.922$, with significance a little above P 0.05; one individual (the smallest, *Lt* 254.0), however, contributing 65% of the negative *dXdY* total. For the remaining 19 examples $r = +0.540$ ($z = 0.605$), $t = 2.647$*, slightly better than P 0.02. A positive correlation of *S* with *Lt* in *M. breviceps* has been reported in earlier contributions (see below).

Comparison with *M. breviceps*

A detailed comparison in Part XIX (1974 a) of the holotype and the first recorded Tasmanian specimen of *M. ogilbyi* with six Tasmanian examples of *M. breviceps* has shown these two species are very closely similar in nearly all gross morphological features; perhaps the only clear and ready distinction between them being provided by the differences in dentition — a feature, however, to which Schultz (1953), with extensive acquaintance with the group, attaches prime importance. Two dimensions for which, in the above material, the *TLt* value of the Tasmanian example of *M. ogilbyi* lies outside the range for *M. breviceps* are: length to dorsal origin, 178 (*cf.* 161-169, $\bar{x}$ 166.1 ± 0.97); dorsal-anal interval, 190 (*cf.* 203-225, $\bar{x}$ 213.9 ± 2.89). At the time it was pointed out that, with such limited material, it was not clear how much importance was attachable to these differences. For the present 20 *M. ogilbyi* length to dorsal origin, as *TLt*, is 159-186, $\bar{x}$ 175.8 ±2.15. Thus for the first relative dimension the lower *M. ogilbyi* value falls (in one individual only) within the *M. breviceps* range; however the difference of the means is a significant one ($t = 3.566$**); for the second relative dimension, though the mean for *M. ogilbyi* remains below that for *M. breviceps*, no fewer than 15 individuals fall within the *M. breviceps* range, the difference of the means being statistically non-significant at $t = 0.775$.

In the original investigation in Part VIII (1957) of the sample of six *M. breviceps* (three localities) it was found Schmidt's index (range 19.14-21.92) exhibited significant linear regression on *Lt*, the equation being $S = 0.007424\,Lt + 17.53$; $t = 4.73$**; mean percentage error of predicted on observed values of $S = 1.3$. For the present sample of *M. ogilbyi* (range 18.86 — 22.57) $S = 0.01194\,Lt + 15.97$; $t = 3.980$***; percentage error of predicted on observed values 0.0—11.1 (smallest individual), $\bar{x}$ 3.5 ± 0.61.

Coloration

As preserved, all specimens exhibit the same general pattern of coloration. Dorsal surface somewhat brownish olivaceous; ventral surface varying from pale to fairly deep yellowish, uniform, immaculate about to level of vent, behind which it is subject to backwardly increasing invasion of brownish from the sides, the light colour being almost or wholly obliterated in the last one-fifth to one-fourth of the tail. On the trunk, and in some individuals in the anterior portion of the tail, the dark upper colour uniform, quite sharply demarcated from the yellowish; in others the dark region on much of the tail may be continued downward in alternating obscure streaks of contrasting intensity, the line of demarcation between upper and lower colours then becoming less definite. On trunk, and on a greater or less part of anterior portion of tail, yellow of ventral surface extending upwards on to flank, to an increasing extent cephalad; continuing on to head to include whole of lower jaw, upper jaw behind orbit; also at times presenting a strip or patch on jaw between anterior and posterior nostrils, flap of latter usually remaining dark. Almost always a small more or less rounded lighter area at tip of upper jaw, commonly extending briefly on to dorsum here.

Dorsal mostly white, whitish, or pale yellow, anal mostly pale or medium yellow, both fins becoming somewhat dusky towards their termination.

TABLE 2

Muraenichthys ogilbyi Fowler, 1908. Dimensions of 20 examples from Greens Beach, northern Tasmania. First line, total length, absolute dimensions, mm: other lines relative dimensions, permillages of total length.

Feature	Range	$\bar{x}$	s	V	Entries within $\bar{x} \pm s$
Total length	254.0 - 489.1	377.1 ± 13.0	58.2 ± 9.21	15.4 ± 2.5	15
Length to dorsal origin	159 - 186	176 ± 1.60	7.17 ± 1.13	4.1 ± 0.6	15
Length to vent	364 - 405	381 ± 2.24	10.0 ± 1.58	2.6 ± 0.4	16
Length to anal origin	369 - 411	386 ± 2.12	9.50 ± 1.50	2.5 ± 0.4	16
Length to front of gill opening	78.2 - 94.8	87.3 ± 0.951	4.25 ± 0.673	4.9 ± 0.8	14
Length to back of gill opening (head) (head)	79.4 - 98.0	90.8 ± 0.994	4.44 ± 0.703	4.9 ± 0.8	13
Snout	15.6 - 22.6	18.5 ± 0.367	1.64 ± 0.260	8.9 ± 1.4	13
Eye	7.5 - 11.1	8.76 ± 0.172	0.767 ± 0.121	8.8 ± 1.4	15
Interorbital	9.9 - 13.9	11.5 ± 0.228	1.02 ± 0.161	8.9 ± 1.4	13
Length to maxilla	37.2 - 59.9	49.2 ± 1.37	6.14 ± 0.971	12.5 ± 2.0	13
Length of upper jaw to rictal membrane membrane	24.7 - 30.7	27.9 ± 0.0370	1.66 ± 0.262	5.9 ± 0.9	13
Length of lower jaw to rictal membrane membrane	21.4 - 27.9	24.8 ± 0.414	1.85 ± 0.293	7.5 ± 1.2	11
Maximum depth of branchial basket	24.9 - 33.6	29.0 ± 0.507	2.27 ± 0.359	7.8 ± 1.2	16
Maximum width of branchial basket	23.5 - 36.5	28.7 ± 0.732	3.27 ± 0.518	11.4 ± 1.8	15
Maximum depth of body	23.1 - 35.0	28.1 ± 0.607	2.71 ± 0.429	9.7 ± 1.5	15
Maximum width of body	21.7 - 29.0	25.1 ± 0.469	2.10 ± 0.332	8.4 ± 1.3	9
Depth at dorsal origin	22.4 - 32.7	27.1 ± 0.719	3.21 ± 0.508	11.9 ± 1.9	11
Depth at vent	22.6 - 27.4	24.9 ± 0.343	1.54 ± 0.243	6.2 ± 1.0	10
Depth midway between vent and tail tip	20.0 - 25.1	22.7 ± 0.353	1.58 ± 0.250	6.9 ± 1.1	14

TABLE 3

Muraenichthys ogilbyi Fowler, 1908. Proportions of 20 examples, total length 254.0 - 489.1 mm, from Greens Beach, northern Tasmania.

Feature	Range	$\bar{x}$	s	V	Entries within $\bar{x} \pm s$
Schmidt's index, *S*	18.9 -22.6	20.56 ± 0.246	1.18 ± 0.187	5.7 ± 0.91	14
Maximum depth in head	2.68- 3.84	3.25 ± 0.0644	0.288 ± 0.0455	7.0 ± 1.1	14
Maximum depth of body in total length	28.5 -43.3	35.9 ± 0.773	3.46 ± 0.546	9.6 ± 1.5	13
Head in trunk	2.91- 3.70	3.20 ± 0.0416	0.186 ± 0.0294	5.8 ± 0.92	11
Head in total length	10.2 -12.6	11.0 ± 0.125	0.559 ± 0.0884	5.0 ± 0.80	14
Head in dorsal-bearing trunk	2.08- 2.42	2.26 ± 0.0226	0.101 ± 0.0160	4.5 ± 0.71	13
Precaudal length in tail	1.47- 1.75	1.61 ± 0.0117	0.0522 ± 0.00825	3.2 ± 0.51	12
Predorsal trunk in total trunk	2.86- 4.21	3.45 ± 0.0743	0.332 ± 0.0526	9.6 ± 1.5	13
Predorsal length in remainder of length	4.33- 5.29	4.71 ± 0.0528	0.236 ± 0.0374	5.0 ± 0.79	16
Predorsal length in length to vent	2.04- 2.33	2.17 ± 0.0209	0.0934 ± 0.0148	4.3 ± 0.68	13
Eye in head	7.6 -12.3	10.5 ± 0.227	1.02 ± 0.161	9.7 ± 1.5	15
Eye in snout	1.50- 2.70	2.13 ± 0.0417	0.187 ± 0.0295	8.7 ± 1.4	16
Eye in interorbital	1.07- 1.56	1.32 ± 0.0295	0.132 ± 0.0209	10.0 ± 1.6	14

E.O.G. Scott

Family EPHINEPHELIDAE

In recent overseas texts — probably influenced directly or indirectly by Berg (1940) — a number of families formerly recognized, among them the Ephinephelidae — Greenwood *et al* (1966) list 18 others — are subsumed in Serranidae. However, in most Australian publications — including such basic references at the Check-list (McCulloch 1929), the Handbook (Munro 1961) and the various works of Whitley — Ephinephelidae accorded familial status. The latter usage is accordingly conveniently followed here — indeed, in any case, as one of the largest known families, with round about 600 species, the Serranidae constitutes an unwieldy assemblage, and there would seem to be tenable grounds for some subdivision of it.

This family, with upwards of fifty Australian members, occurring mainly in the northern States, has hitherto been represented in the Tasmanian list by a single species, *Polyprionum oxygeneios* (Bloch & Schneider, 1801) [in Check-list (McCulloch 1929), in Handbook (Munro 1961) and widely in Australian literature referred to *Polyprion* Schinz, 1882: it would appear (Whitley 1968) *Polyprionum* Bosc, 1818 has priority], which has a wide extralimital range, extending to New Zealand (type locality) and South Africa. A second species, *Acanthistius serratus* (Cuvier, 1828) with Check-list distribution Western Australia (type locality), Queensland, New South Wales, the Handbook adding Victoria, is here reported from a northern Tasmanian locality.

KEY TO EPHINEPHELIDAE RECORDED FROM TASMANIA

A. Dorsal spines XI-XII, rays 12-13. Lateral line 85-90; scales in longitudinal series 140-180. Anal spine III longest. Operculum with horizontal ridge; with one spine. Teeth in jaws villiform, no enlarged teeth, tongue with teeth ..... *Polyprionum oxygeneios*

AA. Dorsal spines XIII, rays 16. Lateral line 60-67; scales in longitudinal series 90 - 110. Anal spine II longest. Operculum without horizontal ridge; with three spines. Teeth in jaws villiform or cardiform with some enlarged outer teeth; tongue edentulous ..... *Acanthistius serratus*

The present fish, while apparently referable to *Acanthistius serratus*, differs in several points, notably in the nature of the scales, from available descriptions of that species: in the circumstances it has been deemed expedient to provide a tolerably full account of the specimen.

Genus *ACANTHISTIUS* Gill, 1863

Acanthistius Gill, 1863, *Proc. Acad. Nat. Sci. Philad.* (1862), p.235, footnote. Haplotype, *Plectropoma serratum* Cuvier, 1828.

Acanthistius serratus (Cuvier, 1828)

Plectropoma serratum Cuvier, 1828, *Hist. Nat. Poiss.*, 2, p.399. Type locality: King George's Sound (Quoy & Gaimard.)
Acanthistius serratus McCulloch, 1929, *Aust. Mus.* 5, (1), p.442, (synonymy).

Material A specimen, *Ls* 129, *Lt* 160, collected at Tam O'Shanter Bay, northern Tasmania, on 20 January 1974; Q.V.M. Reg. No. 1974/5/31 (donor Mr J. Room).

Meristic characters
D.XIII,16. A.111,9. P.18/18. V.I.5. C.14+(4+4). L. late 59+8 on caudal. L.tr. 26/67. Sc.95. Gill rakers on lower limb of anterior arch 7 (left), 8 (right) + 6 low, mounded (on each side).

Chief dimensions

Values as *TLs* are followed in parentheses by measurements, mm. Length to origin, termination (spine bases) of first dorsal 384 (49.5), 725 (93.5); of second dorsal (ray bases) 740 (95.5), 899 (116); of anal 721 (93.0), 876 (113). Length to pectoral origin 380 (49); length of fin from most advanced point on base 267 (34.5), from level of insertion of most advanced ray 244 (31.5); oblique extent of base 87 (11.2). Length to ventral origin 411 (53); length of fin 205 (26.5). Length to vent (middle) 647 (83.5). Head 430 (55.5). Snout, full 115 (14.9), from tip of upper jaw 110 (14.3). Eye 77 (9.9). Interorbital 42 (5.4). Internarial (posterior nostrils) 24 (4.4). Length of maxilla 182 (23.5), greatest width (6.3), shortest distance from eye 39 (5.0). Depth at front of eyes 194 (25), at back of eyes 267 (34.5), at first dorsal origin 372 (48), at opercular border 380 (49). at vent 333 (43); maximum depth 388 (50); depth of caudal peduncle, minimum 124 (16), at second dorsal termination 141 (18.3). Widths at same five points 112 (14.5), 140 (18), 155 (20), 163 (21), 101 (13); maximum width 163 (21); widths of caudal peduncle 16 (2.0), 39 (5.0).

General description

Body form in terms of the specifications of Gregory (1928): hypsisomatic, gasterion postapical, apex anterior, gasterion posterior, mesonotic, bathygastric, nomopygidial, opisthion preuranic.

Elongate ovate, compressed, greatest width 2.4 in greatest depth; latter 2.58 *in Ls*, 0.90 head. Caudal peduncle stout, its least depth 1.3 its length, 3.5 in head. Head large, 2.32 in *Ls*, 1.50 in length to vent. Eye 5.6 in head, 1.5 in snout, 1.8 interorbital; almost cutting dorsal profile; shortest distance from maxilla subequal to width of maxilla at nearest point. Interorbital slightly concave between well developed ridges. Lower jaw projecting a little beyond upper. Mouth cleft strongly oblique. Least oblique width of preorbital half eye, greatest anteroposterior extension equal to eye. Maxilla with supplemental bone, extending to 0.7 eye, its greatest width subequal to direct distance of its posterosuperior angle from orbit. Operculum with three strong spines; middle longest, about half eye, tip just overlapping subtriangular membranous lobe; uppermost about on horizontal level of anterior nostril; lowest smallest, as far as uppermost from middle, divided at tip. Hind segment of preopercular border with 8-9 spines, subequally spaced, in general increasing in size downward; at angle 2 double spines; on inferior border 2 spines, hinder larger, double. Suboperculum, interoperculum entire.

Gill rakers on lower limb of anterior arch 7-8, elongate, subtriangular, minutely spinulose, on left side increasing in length to 5th, which is two-thirds longest gill filament, on right side none longer than 1st (uppermost) and 2nd; below these 6 subcontinuous minutely spinose elevations.

Teeth in upper jaw comprising *(a)* on each side a dentigerous strip extending back for nine-tenths of jaw, its anterior one-fourth widening to form a patch of enlarged subconical recurved teeth, the remainder closely set with small teeth, those in anterior half cardiform, the rest (except for 3 larger, but still small, teeth near rictus on left side) villiform; *(b)* on left side a short anterior outer row of 3 large teeth and 1 moderate tooth; no corresponding teeth on right. In hind half of lower jaw a strip, less than half width of strip in upper jaw, of villiform teeth; in advance of this strip somewhat wider, broadening near symphysis to a patch of cardiform teeth of variable length : an imperfect outer row of larger teeth, comprising on left 3 large, followed after a diastema by 1 moderate, 2 large, 3 moderate, on right 1 large followed after a diastema twice that on left by 3 moderate, 2 large 1 moderate. Vomerine teeth cardiform, in a small lunule. Palatine teeth small, well separated posteriorly, where they are biserial or uniserial; more closely set, in several rows, anteriorly.

Trunk and tail with small scales, largest near middle of side, decreasing towards

profiles and on pectoral base. Scales on head extend forward on dorsum to level of posterior nostrils; cover whole operculum; occur on lateral surface forward to a line from near middle of anterior border of orbit to upper lip (thus including most of preorbital, though deeply embedded, obscure here). On head scales cycloid; on trunk and tail some, especially the smaller ones, cycloid, the majority ctenoid, the spinules 6-12, modally 9-10, largest and strongest in hinder half of fish. Most scales with fine but distinct longitudinal ridges, characteristically forming two series each of 5-9, modally 7-8, curved so as partly to follow scale border, the two innermost ridges continuous with one another in the distal one-fourth, or less, of the scale, but diverging somewhat as they run forward, leaving a narrow lanceolate space between them.

Dorsal originating above about middle of operculum; 13 spines, increasing in length to fourth, which is 3.3 in head, 2.3 first spine, 1.7 last; length to fin 2.61 in *Ls*; spinous base 1.26 in *Ls*, 2.16 soft base; 16 rays, first, last, longest (eighth-ninth) 3.3, 6.9, 3.0 in head. Anal originating below first dorsal ray; 3 spines, first imperfect, second equal to full snout, 1.5 third; 9 rays, first, last, longest (fifth) 3.1, 4.8, 2.4 in head. Pectoral rather large; total length 1.61 in head; distal half approximating a semi-ellipse; extending to middle of vent; 18 rays, first, last, longest (eighth) 3.0, 4.4, 1.8 in head. Ventrals set close together, originating just behind level of lower (more caudad) end of pectoral base; extending barely to front of vent; first (innermost), last, longest (fifth) ray, spine 3.2, 2.3, 2.2, 4.2 in head. Caudal rounded truncate; 14 branched rays, flanked above and below by 4 unbranched; length, from hypural, 1.8 in head.

Coloration

Sides medium brownish, somewhat darker above, noticeably lighter below a line from pectoral base to vent. Trunk and tail marked with some four score dark brown or blackish spots, showing some tendency to form half a dozen longitudinal series; spots involving 3-12, modally 6-8, scales; extending on to hinder part of head. Spinous dorsal dark olivaceous. Soft dorsal successively deep brown, greenish yellow, brownish. Anal mainly dark brownish, lighter proximally, approaching black distally. Pectoral successively yellowish brown, dark brown, yellowish (well developed arc), dusky. Ventral mainly dark brown, lighter proximally, blackish distally.

Specification of length of dorsal spines

An introduction to these length-number relationships of fin spines and fin rays is to be found in Part XIX of these Observations (1974 a, p.248): see also Part XX (1974 b).

The length, L, in ascending set (*i.e.*, those increasing in length caudad) of dorsal spines {I-IV} is given by the relation $L = bN^k$, where N is serial number of spine, in the relevant set, counting caudad; that of the descending set {V-XIII, omitting IX, imperfect} by $L = bN^{1(k)}$, where N^1 is serial number of spine, in the relevant set, counting cephalad. These relations are conveniently plotted as linear graphs with equations $\log L = k \log N + \log b$, $\log L = k \log N^1 + \log b$.

With measurements in mm, k for the ascending series is 0.6133, for the descending series 0.2232, $\log b$ being 0.8574, 0.9930. Significance of the regressions is high; $t = 141.708^{***}$, 34.079^{***}. Predicted lengths, $\tilde{L}$, with measured length, L, in parentheses: 7.2(7.2), 11.0(11.0), 14.1(14.2), 16.9(16.8) and 16.1(16.0), 15.7(15.5), 15.2 (15.0), 14.7(14.8), —(—), 13.4(13.6), 12.6(12.8), 11.5(11.5), 9.8(9.7).

Specification of length of four ventral rays

For $N = \{1\text{-}4\}$, $L = bN^k$, with $k = 0.2784$, $\log b = 1.2418$; $t = 9.966^{**}$; $\tilde{L}$ (*L*) = 25.7(25.1, .7(24.5), 21.2(21.0), 17.5(17.4). The formulation for the two-member set of ray 5 (23.8 mm) and spine (13.1 mm) is in itself trivial; and no articulation of it with the set {1-4} has been found.

Specification of length of pectoral rays

Calculations are for right fin. An equation of the form $L = bN^k$ is applicable to the formally earlier (upper) rays in two sets, {1-3} , {4-8} , and an equation of the form $L = bN^{1(k)}$ to the remaining rays in three sets, {9-11} , {12-15} , {16-18}. Values of k, in sequence from {1-3} , are 0.3202, 0.04331, 0.02803, 0.0917, 0.3000; of log b 1.2672, 1.4467, 1.4546, 1.2868, 1.0962; t = 86.242**, 3.599*, 19.156*, 48.380***, 43.196*. From the several equations, $\widetilde{L(L)}$ =18.5 (18.5), 23.1(23.1), 26.3 (26.3), 28.0(28.0), 28.8(28.9), 29.3(29.4), 29.7(30.0), 30.0(30.2), 29.4(29.4), 29.0 (29.0), 28.5(28.5), 25.2(25.3), 23.9(23.9), 22.2(22.0), 19.4(19.4), 17.4(17.4), 15.4 (15.3), 12.5(12.5).

It will be seen the specification of the pectoral rays calls for the recognition of five sets — the existence of several sets has been found usual in other species examined, the curve of this fin being, at sight, more complex as a rule than that of the dorsal or the anal. As pointed out earlier (1974 a. p.250), the situation arising from the employment of a multiplicity of sets could, in the limit, resolve itself into a triviality, comparable to the formulation of the circumference of a circle by the specification of the perimeter of a polygon with a number of sides appropriate to the degree of precision deemed desirable. However, the actual plotting of the (logarithmic) length-number co-ordinates yields such clear visual evidence of linearity over successive small ranges associated with marked changes of gradient at points of inflection that it appears difficult not to attribute some validity to the overall pattern that thus presents itself. Possible indications of the status of the several graphs as indications of genuine morphological patterns are provided by the following relationships subsisting among them. The two sets of the ascending series are matched, in respect of mean log length of ray, with the first two of the descending series, these lengths, in succession caudad, being 1.350, 1.467, 1.461, 1.353. When compared in respect of area below the graph, these two pairs again match, but with different partners, the areas in sequence as before being 0.641, 1.02, 0.645, 1.01. It would appear unlikely these cases of symmetry (the latter rendered more striking by the fact that the coupled sets differ in number of members) are purely coincidental. When the descending series of three sets is examined, it is found the plot of mean ray length (in sequence cephalad, as in the length-number equations for these sets) on logs of integral 1,2,3, is linear with a fit better than P 0.01 (t = 90.061**); the equation being log L/n = 0.6022 log N^1 + 1.1734, with log L/n, as measured, 1.1741. 1.3529, 1.4619, as predicted, 1.734, 1.3547, 1.4608.

Anal spines

Of the anal spines only the second (14.9 mm) and the third (9.7) are intact.

Discussion

As noted above, the present specimen, while pretty clearly determinable as *Acanthistius serratus*, exhibits some differences from published accounts. A comparison with data at hand — the original account by Cuvier *in* Cuvier & Valenciennes (for a photocopy of which I am indebted to Miss Joan Dixon, Curator of Vertebrates, National Museum of Victoria), of which rather less than half treats of external features; the Handbook diagnosis (Munro 1961, p.161) and the tolerably detailed account by Günther (1859, p.161, pl. 12 cited, but apparently no plates bound) of his *Plectropoma cyanostigma* (name amended in addenda to *P. ocellatum*), this species generally being treated, as in the Check-list (McCulloch 1929a) as synonymic with *A. serratus*, together with the reproduction by McCulloch (1921, p.16, fig. 163a) of the figure by Quoy & Gaimard (1824, pl. 2,1) and the reproduction by Whitley (1962, fig. on p.89) of a figure by Steindachner — yields the following results; minor variations being disregarded. In each case our datum is given first.

Dorsal rays 16 (G.15). Anal rays 9 (G.8). P.18 (C.15; M.19-21). Scales in longitudinal series 95 (G.100, as 'lateral line'). L. lat. 59+8 on caudal (M 60-67). Sc.tr. 26/67 (M 20-22/55-60). Gill rakers on lower limb of anterior arch 7-8 sabre-shaped, followed by 6 low mounded (M.9-10; 'long' — low elevations on lower part

of arch probably not counted); depth in total length 3.2 (G.4), eye in head 5.6 (G.6); maxilla to 0.7 eye (M.to or beyond hind edge of eye); lower jaw projecting slightly (C.'les deux mâchoires sont d'égale longueur'); base of spinous dorsal 2.0 (G.1½; C.'beaucoup plus longue') base of soft dorsal; twelfth dorsal spine 1.4 times (G. rather shorter than) second; first dorsal ray 1.5 times (G. one-third longer than) last spine; pectoral reaching to (Q. & G.'s figure well short of) vent; preorbital obscurely squamous, scales deeply embedded (G., M. naked); upper and lower jaws naked (C.'De petites écailles recouvrent la peau du maxillaire et de la mâchoire inférieure'); the teeth forming bands in the jaws, in parts villiform in parts cardiform (C.'en cardes .... assez fortes'; M.villiform); in upper jaw outer series of large teeth 4 only in front on right side, none on left (C."les dentes de la rangee externe sont fortes, courtes, coniques, un peu crochues et d'égale longueur; G.'a series of large teeth in each jaw in front and on the side'; M.'both jaws with ... an outer row of enlarged conical' teeth); opercular spines rather blunt (C.'très-acerées); caudal truncate (Q. & G.'s figure emarginate) — however, it may be noted that in the closely allied *Plectropoma maculatum* (Bloch, 1790) the caudal is stated to be truncate in the young fish, becoming emerginate with age; Quoy & Gaimard's figure shows soft dorsal and anal less rounded, pectoral more rounded than Steindachner's (latter agreeing better with our specimen); places ventral origin (incorrectly) in advance of pectoral origin. As preserved in alcohol, the specimen shows no sign of the dark bar noted by Cuvier as running from eye towards angle of preoperculum; on the contrary the greater part of the cheek is lighter in colour than rest of head. Nor is there any obvious indication of the bluish centre to the blackish spots reported by Günther — noticed also in a popular account by Whitley (1962, p.89), this author noting also 'sometimes about 4 transverse dark and light bands', and remarking the blue spots may be few or absent.

The most striking feature of the Tasmanian fish is the presence of both cycloid and ctenoid scales (latter developed mainly in hinder part of body). Miss Joan Dixon, has been good enough to arrange for her assistant, Miss Linda Chegwidden, to examine the scales in a Victorian example of *A. serratus* (Reg. No. A16, Mallacoota, purchased 1933): in this fish also both types of scale occur. No reference to the nature of the scales appears either in Cuvier's description of *A. serratus* or in Günther's account of *P. cyanostigma*. However, Munro's diagnosis, under the former name, has 'Scales cycloid'. It should be remarked that the presence of both cycloid and ctenoid scales (the former usually confined to the head) is not uncommon in the allied *Epinephalus* Bloch, 1793, upwards of half a dozen Australian species of this genus being so characterized. A particularly interesting situation obtains in *E. tauvina* (Forskal, 1775), in which the scales are ctenoid early but become cycloid with age. As the length of our specimen of *A. serratus* is only about one-third of the full size, it could be its possession of mixed scales is a subadult feature. On the other hand, in view of the fact that the type locality of Cuvier's species is King George's Sound, Western Australia, consideration deserves to be given to the possibility that differences from published accounts presented by our fish are indicative of the occurrence in our waters of an eastern subspecies — a matter towards the elucidation of which the above description may serve as a first step.

Family SCORPIDAE

Genus *ATYPICHTHYS* Günther, 1862

Atypichthys Gunther, 1862, *Cat. Fish. Brit. Mus.*, 4, p.510. *Nom. nov. pro Atypus*, Günther, 1862 preocc. in Arachnida. Haplotype, *Atypus strigatus* Günther.

Atypichthys strigatus (Günther, 1860)

Atypus strigatus Günther, 1860, *Cat. Fish. Brit. Mus.*, 2, pp.64 and 518. Type localities: Swan River, W. Australia; Holdfast Bay, S. Australia; Raoul Is.; Erromanga, New Hebrides.

Atypichthys mado Whitley, 1911, *Aust. Zool.*, 6 (4), p.319. Type locality: Manly, New South Wales.

Additional records

The mado was first recorded from Tasmania in Part XX (1974 b) on the basis of three examples from George Bay, east coast, together with reports from scuba divers of its occurrence at Stony Head, north east coast, and Clarke Island, Furneaux Group, Bass Strait. Several examples from Boat Harbour, north west coast, collected by Mr H.J. Griffith have since been added to the Queen Victoria Museum's collections: among these are two juveniles, *Ls* 20.2, 21.9, *Lt* 23.9, 25.1, taken on 17 March 1974, (Q.V.M. Reg. No. 1974/5/122) that are here made the subject of some observations, chiefly on relative growth and development of colour pattern.

Relative growth

Comparisons of some dimensions expressed as permillages of standard length of the George Bay individuals (*Ls* 102.1, 104.5, 110.2) set out in Part XX with those of the present juveniles reveal regional variations of relative size with age. Consistently higher (though not necessarily statistically significantly greater) values of *TLs* are found in the younger fish for most dimensions involving anterior features: head 323, 361 (*cf.* 293, 278, 272), t = 2.987, snout 94, 82 (67, 67, 64), t = 4.726*, eye 149, 151 (98, 95, 92), t = 23.335***, length to (spinous) dorsal origin 386, 393 (326, 331, 335), t = 14.293***; an exception being provided by the transverse measurement, interorbital width 74, 89 (101, 99, 95), t = 2.057.

On the other hand, the posterior dimensions length to (soft) dorsal termination 792, 772 (911, 863, 833), t = 4.633*, length to anal termination 812, 813 (917, 883, 871), t = 4.375*, are consistently less in juveniles. Lower *TLs* values, again with the young and old sets disjoint, obtain in the present material in respect of depth at opercular border 337, 320 (411, 392, 404), t = 6.610**, depth at spinous dorsal origin 347, 338 (470, 440, 454), t = 22.285***, depth at vent 353, 365, (470, 440, 386), t = 2.247, maximum depth 396, 384 (495, 459, 481), t = 6.200**; the greatest proportional increase in relative depth occurring at the origin of the spinous dorsal, where the mean value of the older fish is one and one-third times that of the younger fish. Of the three small *TLs* magnitudes depth at front of eyes, depth at back of eyes and depth of caudal peduncle the first has the lower mean value among the juveniles (though the two sets intersect), the variates being 149, 155 (197, 163, 150), t = 0.988; higher relative depths occurring in both the present specimens at back of eyes 302, 297 (289, 292, 288), t = 4.574* and at caudal peduncle (minimum) 119, 119 (118, 118, 109), t = 1.033.

Development of colour pattern

In these juveniles the colour pattern — the full occurrence of which in the George Bay specimens is the subject of detailed description in Part XX (1974 b, p.183) — is in a rather early stage of formulation, only the upper (in the adult, widest, most intense) stripes being developed. The general situation in the larger individual is as follows.

Uppermost black stripe at dorsal profile thin, extending to within 4-5 rays of end of dorsal: second beginning at profile about midway between eye and dorsal origin, continuing back, well developed, to superior profile of caudal peduncle just behind dorsal termination: third extending from near highest point on orbit to middle of caudal peduncle, ceasing as a continuous line an eye diameter in advance of hypural joint, represented thereafter only by a few dark specks: fourth effectively constituted as a stripe only from middle of orbit to about half an eye diameter beyond opercular border, continuing behind this, for a slightly greater distance, only in the form of dots (which, however, fairly clearly delimit its width), wholly ceasing, just above anal base, about one and one-third eye diameters short of hypural; no indications of other stripes (in adult usually three more); the abdominal viscera apparent as an off-white or pale yellowish ovoid, visually undifferentiated mass, about half as long

again as deep; this region conspicuously patterned with 40-50 melanophores of varying size. many 0.1 mm, or less, in diameter, several 3-4 times as large; dotted area extending on to head, covering most of the cheek below fourth stripe forward nearly to level of front of eye, melanophores subequal; dorsum of head with forward continuation of second stripe, interstripe region without many chromatophores, but stripe liberally sprinkled with melanophores much larger and more intense than the microscopic ones marking its general course; median portion of upper border of upper lips slenderly margined with blackish; ventral surface mostly off-white, whiter on chin; immaculate save for a few dark splashes on throat; some dark lines on spinous dorsal; soft dorsal, anal, pectoral quite colourless; ventral greenish with some dark spots; caudal with a vertical line of half a dozen spots across base.

The smaller specimen agrees broadly with the larger one. Chief differences: overall effect of second and third stripes a trifle lighter; portion of fourth stripe running back from mid-orbit stopping at opercular border, with short hiatus (about half an eye diameter) between it and its extension on to trunk; dark line on upper lip not continuous; melanophores on cheek include several larger, less sharply delimited ones; marking on caudal base two obscure dark patches.

It thus appears that the sequence of development of the conspicuous longitudinal stripes so characteristic of the species is primarily from the dorsal profile ventrad, while within the stripe itself differentiation is initiated anteriorly and proceeds caudad.

Life colours

The specimens, examined while tolerably fresh, exhibited overall coloration probably not differing markedly from that in life — first dorsal pale greyish with large yellowish patches; dark brown marginal band; spines (strongly projecting) white; second dorsal pale yellowish, delicately tipped orange; anal from base successively whitish, briefly yellowish, darker and somewhat brownish, yellowish, some delicate orange tipping; pectoral yellowish or pale orange proximally, more or less colourless distally; ventral white, tipped greenish yellow; caudal proximally pale orange; indications of two dusky arcs near middle of length; beyond this yellowish, soon becoming lighter, distally approaching white.

Size, habits

Whitley (1962, p.158) observed, 'Rarely 10 in., usually much smaller.' When forwarding examples of a total length of round about 150 mm, Mr Griffith noted that these were about as large as any he had met with. He added 'We [*i.e.*, local scuba divers] have seen them on various occasions between Wynyard and Sisters Beach in groups of 3 or 4, and once in a school of about a dozen at Boat Harbour. They normally occur in depths around 40 ft or so', [*ca* 12 m].

Family TRICHIURIDAE

While the Handbook (Munro 1958) recognized the Lepidopidae as a separate family — represented in Australia by three genera, *Lepidopus* Gouan, 1770, *Benthodesmus* Goode & Bean, 1882 [regarded by Whitley (1968, p.74) as a synonym of *Scarcina* Rafinesque, 1810], *Assurger* Whitley, 1933, each with a single species; only the first recorded from Tasmania — a procedure recently followed by Scott *et al.* (1974), Lepidopidae was subsumed by Greenwood *et al.* (1966) in their overall provisional Teleostean classification in Trichiuridae, thus reverting to the usage general among earlier authors — *e.g.*, Günther (1881), Boulenger (1910), Jordan (1923), McCulloch (1929), Berg (1940) — and that adopted in the local lists of Johnston (1882), Lord (1923, 1927), Lord & Scott (1924), and in the present Observations.

Genus *LEPIDOPUS* Gouan, 1770

Lepidopus Gouan, *Hist. Pisc.*, pp.107 and 185. Haplotype, *L.gouani* Gouan = *Trichiurus caudatus* Euphrasen.

Lepidopus caudatus (Euphrasen, 1788)

Trichiurus caudatus Euphrasen, 1788, *K. Vet. Nya. Handl.*, 9, p.52.
Lepidopus caudatus McCulloch, 1929, *Aust. Mus. Mem*, 5 (2), p.267 (synonymy).
Lepidopus lex Phillipps, 1932, *N. Z. J. Sci. Techn.*, 13 (4), p.232. Type locality: 'all parts of New Zealand'.

Material

(a) An example, *Ls* 1302, *Lt* 1365, hooked at a depth of 150 fms (274 m), east of Scamander, east coast, by Mr A.W. Yates (Q.V.M. Reg. No. 1975/5/140); (b) a specimen, *Ls* 1461, found by Mr E. Bennett in 1943 in shallow water at Little Devil's Elbow, Tamar river, 40-45 km from river mouth (Q.V.M. Reg. No. 1943.78): the latter was the subject of some observations in Part IX of this series (1960, p.62).

Meristic characters

Data in parenthesis in this section relate to specimen (b). D. 103 (100). A. *ca* XXXII, embedded ('numerous'), 28 (25). P. 12 (12), lowermost, uppermost 2 unbranched (2 broad, undivided). C.10+1+10 (18-20 principal rays). V. rudimentary, represented by 2 scales.

Dimensions and proportions

Where two values appear, the second relates to specimen (b). Lengths and 'length to' measurements are made from tip of lower jaw, which projects beyond upper by 13, 9 mm.

Length to dorsal origin (156, 143 mm) 8.35, 9.86, to termination (1273, 1368), 1.02, 1.03; to anal origin (spine) (728) 1.79 or (ray) (1208, 1180), 1.80, 1.21, to termination (1276, 1373), 1.02 1.04 in *Ls*. Length to vent (middle) (715, 723) 1.82, 1.95 in *Ls*. Length to pectoral origin (223, 222) 5.84, 6.35 in *Ls*, length of fin (107) 1.22 in *Ls*, or 1.98 in head. Length to ventral origin (271, 277) 4.80, 5.09: left ventral scale, length (9), width (4); right, length (10.5), width (6). Depth at front of eyes (66) 19.7, at back of eyes (80) 16.3, at dorsal origin (90) 14.5, at opercular border (102) 12.8, at ventral origin (maximum depth) (105) 12.4, at vent (103) 12.6 in *Ls*. Depth of caudal peduncle (7, 7) 3.71, 5.28 in its length (26.37). Width at back of eyes (41, 43) 5.17, 4.93, at dorsal origin (43) 4.93, at opercular border (38, 42) 5.58, 5.05 in head.

Head (212, 212) 6.14, 6.44 in *Ls*, or 6.44, 6.88 in *Lt*. Eye (35.5, 39) 5.97, 5.44; snout from tip of upper jaw (7.9, 8.6) 2.68, 2.58, from tip of lower jaw (92, 95) 2.30, 2.23; soft interorbital (32.5, 35) 6.52, 6.06 bony (26.8, 28) 7.91, 7.57 in head. Length of 8th (first intact) dorsal ray (37.8) 5.61, 9th (36.3), 5.84, 13th (40.6) 5.22, ray at level of vent (longest) (42.7) 4.96, last (17.3) 1.23 in head. Some dorsal ray lengths in specimen (*b*): longest, 1st (39) 5.44; shortest, 100th (19) 11.1; 11th, 21st, 31st .. 91st (28, 31, 32, 23, 28, 23, 29, 31) 7.57, 6.84, 6.61, 9.92, 7.57, 9.22, 7.31, 6.84 in head. Length of 1st anal ray (13.0, 5) 16.3, 42.4, last (15.4) 13.7 in head. Spread of caudal (90, 87) 2.36, 2.44 in head. First anal ray below 79th, 77th dorsal ray. Some anal ray lengths in (*b*): 11th (18) 11.8; 21st (12) 17.7; 25th (11) 19.3 in head.

General features

Dorsal begins behind eye by 0.9, 0.6 eye. Maxilla in (*a*) failing to reach level of eye by 0.1 eye diameter, but gape extending to below 0.2 eye [in (*b*) maxilla (= gape?) recorded as to 0.2 eye]; its distance from eye subequal to its distal width.

Ventral at, or slightly in advance of, level of middle of adpressed pectoral, behind border by 0.31, 0.33 length of head: this locates it relatively further forward than in the figure by Whitley (1962), where it is shown under about last one-fifth of pectoral, or behind operculum by about half head, but further back than in the figure by Günther (1880), in which it appears shortly behind dorsal base, or behind operculum by about one-fifth head.

The following observations relate to specimen (*a*). Teeth in left upper jaw 28, in right 25, slender, somewhat compressed, acute, straight or very slightly curved forward, longest (about 0.1 eye) near middle of series; these teeth in lower jaw much as in upper, but somewhat smaller, rather less closely set. One large fang at front on either side of upper jaw, inserted internal to series of small teeth, left 10.5 long, right, situated a little further back, 8. Palatine teeth minute, 0.5 mm or less in a single series along each bone. The base of the caudal is largely occupied by a fleshy region, shaped roughly like the fin itself, its posterior width half width of fin at that level, its length about half length of median rays; anteriorly it is constituted by a noticeable smooth subcircular pad (adipose?), its diameter approximately half total anteroposterior extension of whole feature: all the region is bluish black, the pigmentation heaviest on the pad.

Dorsal marking

Accounts agree in describing the frost-fish as being almost devoid of any distinctive colour patterning, the head and body being more or less uniformly silvery, the fins largely unmarked (outer margin of dorsal, or parts of it, may be very narrowly bordered with black or blackish, caudal may in part be dusky): however, a black or blackish blotch is characteristically found at, and extending for a short or moderate distance inwards from, the distal margin of the membrane between the first three dorsal rays (not shown in figure reproduced in McCulloch). It is of interest to note that while in the present specimen, in which remnants of the membrane associated with the anterior two or three of the first seven imperfect rays (represented only by a few millimetres of their bases) retain traces of apparently normal pigmentation, another well developed black blotch is present at the new effective beginning of the fin, occupying the outer one-third or more of the membrane between the 9th and 11th rays — suggesting perhaps that the loss of the original anterior rays has resulted from some injury, and that in their absence some stimulus has operated to bring it about that the region of these normally later rays, located above the pectoral instead of above the head, now effectively the anterior ones, are pigmented by virtue of their mere anteriority.

Status of the Australian *Lepidopus*

The table of species synonymy in the Australian Check-list (McCulloch 1929) comprises 10 entries, involving 8 second binomens : these references, however, are all extra-Australian and call for no comment here.

The history of the frost-fish in Australian and New Zealand literature divides into three epochs, the first prior to 1932, during which our fish was customarily identified as the Atlantic and Mediterranean species, *L. caudatus*, the second following the publication in that year of *L. lex* that saw Phillipps' name applied to the Australasian fish, the third characterized by a recent recognition of the existence of a single species in both hemispheres. Thus, among local authors, Allport (1876, p.86), giving the first record for Tasmania, based on an example washed ashore at Battery Point, Hobart, Macleay (1881), Johnston (1883, 1891), Lord (1923, 1927), Lord & Scott (1924), McCulloch (1922, 1929), all have the former name : Munro (1958), Scott (1960), Whitley (1962, 1964; also in New Zealand Check-list 1968), Scott (1962), Scott *et al.* (1974) have the latter: however, Marshall (1964) accepts *L. caudatus* (in index *candatus*) as also do the New Zealand authors Heath & Moreland (1973).

Phillipps' account is a somewhat sketchy one, unaccompanied by any dimensions

other than length and weight, or by any actual fin counts. His comparison with the established species, based partly on a figure by Goode & Bean, takes account of five main features — fewer dorsal rays, fewer anal rays, longer head, sixth dorsal ray 5 (*cf.* 8 or more) in head, no dorsal 'spines' [rays] exceeding eye diameter.

A point by point comparison (set out in full in the original draft of the present paper) of our material with available accounts and figures in Australian works, together with the description by Günther (1860, p.345) resulted in the conclusion that it is not separable from *L. caudatus*. It now appears, however, that the invalidity of *L. lex* has been satisfactorily established previously, and the writer is much indebted to Dr John Paxton, Curator of Fishes, Australian Museum, Sydney, for calling attention to the fact that Tucker (1956) has dealt with the synonymy of *L. caudatus* and after directly comparing specimens of the frost-fish from New Zealand and the North Atlantic placed *L. lex* in the synonymy of Euphrasen's species. Tucker has been followed, Dr. Paxton adds, by Parin & Becker (1972): as references cited above make clear, however, his conclusion has not hitherto been widely incorporated in local texts.

Family SOLEIDAE

Genus *ZEBRIAS* Jordan & Snyder, 1890

Zebrias Jordan & Snyder, 1890, *Proc. U. S. Nat. Mus.*, 23, p.38. Orthotype, *Solea zebrias* Temminck & Schlegel.

Zebrias fasciata (Macleay, 1882)

Synaptura fasciata Macleay, 1882. *Proc. Linn. Soc. N.S.W.*, 7 (1), p.14. Type locality: Port Jackson.

Tasmanian records.

It was not until upwards of four-score years after the publication of the first Tasmanian catalogue (Johnston 1883) that this species appeared in the State list, one example, *Ls* 131, from between East Sandy Cape and Thirty Day Island, and a second, *Ls* 96, from off Prime Seal Island, Furneaux Group, being reported in Part XXI (1975). A third example, *Ls* 140, (Q.V.M. Reg. No. 1975/5/156) taken off St Helens, east coast, by the same collector, Mr P. Armstrong, provides a new locality. Two accompanying smaller soles, the larger 113 in standard length, both in a poor state of preservation, are probably referable to this species.

Family GOBIESOCIDAE

The clingfishes, characterized by the incorporation of the ventral fins into a distinctive adhesive apparatus, and constituting the Gobiesocidae, the sole family of the order Gobiesociformes (Xenopterygii), are to be met with, usually in shallow water, on most warm-temperate and some tropical coasts. 'This order seems to be most closely related to the Haplodoci, but there is also some slight resemblance to the Callionymoidei. It may be considered a highly specialized divergence from a primitive percomorph stock' (Briggs 1962, p.444).

Of just under a hundred species noticed by Briggs in his admirable monograph (1955), three are known to occur in Tasmania: *Creocele cardinalis* (Ramsay, 1882) (endemic), *Aspasmogaster tasmaniensis* (Gunther, 1862) (all states except Queensland), *Cochleoceps spatula* (Gunther, 1861) (Tasmania, Victoria, South Australia, Western Australia). Some notes on the history of the family in Australian literature to that time, with a key to the Australian species as then recognized, have been given in Part III of this series (1936), together with some observations on *Aspasmogaster tasmaniensis* (with figure of a Tasmanian example) and on *Creocele cardinalis*.

While the three Tasmanian Clingfish agree in having the adhesive apparatus constituted of an anterior lunule bearing the ventral rays and a posterior subcircle, each closely beset laterally with small flat dermal papillae but having a smooth central region, they differ trenchantly in detailed pattern. In *Aspasmogaster tasmaniensis* there is within the two bare areas only a single group of papillae, wholly confined to the posterior half of the apparatus. In the two other species the papillose island in the hind half presents a well developed forward extension reaching into the lunule: in *Creocele cardinalis* this extension is a four-pointed star, the hindmost arm the longest, overall longer than wide; in *Cochleoceps spatula* the extension is three-sided, all borders convex caudad, the posterior border about twice as long as each of the anterior, overall wider than long. These disc patterns of papillae are generic, while the general nature of the whole apparatus as a double disc (as here) or a single disc is taxonomically significant at subfamily level.

Attachment or non-attachment by membrane of dorsal to caudal base — employed in keys by the writer (1936,p.120) and by (T.D.) Scott (1954, p.110) — is not a satisfactory differentia.

Subfamily TRACHELOCHISMINAE

Genus *Creocele* Briggs, 1955

Creocele Briggs, 1955, *Stanf. Ichth. Bull.*, 6, p.12, figs 15, 43, map 1. Orthotype, *Gobiesox cardinalis* Ramsay.

Creocele cardinalis (Ramsay, 1882)

Gobiesox cardinalis Ramsay, 1882, *Proc. Linn. Soc. N.S.W.*, 7 (2), p.148. Type locality: George Town, Tasmania.
Diplocrepis cardinalis Waite, 1906, *Rec. Aust. Mus.*, 6 (3), p.204, pl. 36, fig. 2 (text cites fig. 1, legend to plate gives fig. 4, notation on plate is 2).
Id. McCulloch, 1929, *Mem. Aust. Mus.*, 5 (3), p.360.
Volgiolus cardinalis Whitley, 1935, *Aust. Mus. Mag.*, 5 (9), text fig. on p. 292.
Id. Scott, 1936, *Pap. Proc. R. Soc. Tasm.* (1935), p.123.
Creocele cardinalis Briggs, 1955, *Stanf. Ichth. Bull.*, 6, p.12, figs 15, 43, map 1.

Appearance in Tasmanian lists

Not included in main body of Johnston's first list; appears, without locality data, in Addenda (1883, p.143) as *Diplocrepis cardinalis;* listed under same name in Johnston's second list (1891, p.33), Lord (1923, p.71), Lord & Scott (1924, pp.14 and 89), Lord (1927, p.16).

Distinguishing features

In addition to the distinctive pattern of the disc, *Creocele* exhibits three features that mark it off sharply from the two other Tasmanian genera: gills three and a half (others three), vent much closer to disc than to anal fin (noticeably closer to anal), presence on lower pectoral base of a prominent fleshy pad with a free posterior margin, from which genus derives its name (*kreas*, flesh; *kele*, a swelling) (no such pad).

Creocele, which is monotypic, is regarded by Briggs as the most primitive known clingfish. It is characterized by the pectoral pad already mentioned, a strong, subopercular spine, a much larger disc and greater overall size than other members of the Trachelochisminae; further, it shares with the six other members of the subfamily a primitive dental arrangement in the form of patches of undifferentiated conical teeth.

Remarks

It is of interest to note that the most primitive genus of the Diplocrepinae, *Diplocrepis* Günther, 1861, a monotypic genus confined to New Zealand, resembles

Creocele in possessing a well defined pectoral pad (represented in some other forms by a slight swelling, rarely developed into a true pad), and a particularly stout, rather simple pelvis, broadly subtriangular when viewed from below, not matched, as far as known, in any of the remaining thirty-odd genera. Pointing out that the complete absence of fossil material makes it necessary to depend on relict species for information on the distributional and evolutionary history of the family, Briggs (1955, p.150) observed 'The remarkable survival of *Creocele* ... in Tasmanian waters ... has been fortunate'; he comes to the conclusion that our shallow waters are evidently cold enough to prevent effective penetration and competition from the several more advanced species common elsewhere in Australia.

Material.

Ten specimens, lettered in sequence of ascending magnitude of *Ls*: (*a*) *Ls* 25.0, *Lt* 31.0, Falmouth, east coast, 31 October, 1970, E.O.G. Scott; (*b*), (*c*), (*d*), (*e*) *Ls* 33.0, 34.0, 35.4, 37.4, *Lt* 41.2, 41.5, 43.0, 46.0, Fisheries, Burnie, north west coast, 26 September, P. Sims, Q.V.M. Reg. No. 1953/5/6; (*f*), (*h*), (*i*), *Ls* 39.5, 48.0, 49.0, *Lt* 48.4, 57.4, 59.0, locality unknown, probably northern Tasmania, Broadland House School; (*g*), *Ls* 40.7, *Lt* 48.9, Brown's Bay, Ulverstone, north west coast, 31 December 1939, E.O.G. Scott, Q.V.M. Reg. No. 1975/5/215; (*j*), *Ls* 50.3, *Ls* 62.1, Low Head, north coast, R. Vogelpoel.

Meristic data.

Fin counts for the type specimen (Ramsay 1883, p.148) were D.8; A.6; V.4; P.22; C.18-20 [minor rays evidently included]. Briggs, with 17 specimens at hand, reported D.9 (9-10); A.7 (6-7); P.25 (24-25); C.11 (10-12), the first figure being the arithmetic mean, the figures in parentheses the range. Our values (counting only clearly visible elements; in caudal, major rays only) are D.8 (6), 9 (4); A.5 (5), 6 (3), 7 (2); P. (left/right) 23/23 (2), 23/24 (2), 24/24 (4), 25/24 (2); C.11 (6), 12 (4), the figures in parentheses being the number of specimens. It will be seen that our D. and A. values are lower than those of Briggs: this is perhaps to be accounted for by our failure to include possible rays wholly embedded in the membrane and not externally visible. With six examples before him, Waite (1906, p.204) gave a single count for each fin, namely, D.10; A.7; P.22; C.11.

Dimensions.

Apart from several records of total length and standard length, no absolute measurements of this species have been published. Measurements, to the nearest tenth of a millimeter, have been made for some three dozen dimensions on each of our 10 specimens. For convenience of comparison, these have been converted to thousandths of standard length, and ranges and means are presented in this form in table 4. For the *TLs* values in excess of 100 the entry provides three (for *TLt* four) significant figures — the last figure always makes possible the recovery of the absolute dimension; however, in general (excluding *TLt*) the values are usefully read to an integral percentage. In most cases they have been taken between parallels: however, the last six entries call for comment. These are made by the methods of Briggs; dorsal-caudal, postdorsal-caudal, length of caudal peduncle being the intervals, found by dividers, between, in each case, midcaudal base and first dorsal ray, last dorsal ray, last anal ray, respectively. Snout is measured from the median anterior edge of the upper lip to the anteriormost edge of the externally visible eye. Chin-disc and interorbital are both taken with dividers, the latter being, as in Briggs, the bony interval, the soft interval being recorded earlier in the table.

Proportions.

Values have been calculated for each of the nine proportions recorded in the species diagnosis in the monograph by Briggs. Each entry below gives arithmetic mean (with standard error), range, coefficient of variation (with standard error), followed, after a colon, by arithmetic mean, range in his material.

Greatest depth in *Ls* 4.92 ± 0.22, 3.9-6.0, 14.0 ± 3.2: 5.4, 4.9-6.0. Depth of caudal peduncle in its (Briggsian) length 0.98 ± 0.34, 0.74-1.07, 11.0 ± 2.5: 1.0, 0.9-1.1. Length of head in *Ls* 2.49 ± 0.43, 2.3-2.7, 5.5 ± 1.2: 2.4, 2.3-2.5. Width of head in *Ls* 2.74 ± 0.50, 2.5-3.1, 5.8 ± 1.3: 2.6, 2.5-2.8. Snout (Briggsian) in head 2.94 ± 0.10, 2.5-3.7, 10.8 ± 2.4: 3.2, 3.0-3.3. Eye in bony (Briggsian) orbital 1.71 ± 0.10, 1.2-2.3, 19.3 ± 4.4: 1.3, 1.1-1.6. Eye in head 6.15 ± 0.17, 5.4-7.1, 8.8 ± 2.0 : 5.5, 4.7-6.0. Postdorsal-caudal distance in dorsal length 1.33 ± 0.042, 1.1-1.6, 10.6 ± 2.4: 1.2, 1.0-1.3. Disc length in *Ls* 3.07 ± 0.058, 2.8-3.1, 6.0 ± 1.3: 2.9, 2.8-3.0.

As noted above, Briggs measures caudal peduncle length with dividers from base of anal ray to midcaudal base, and snout length from median anterior edge of upper to anteriormost edge of externally visible eye: these methods were observed in making the measurements above. With the more usual procedure of taking the measurements between parallels the results are as follows. Depth of caudal peduncle in its length, with length measured from level of last anal ray 0.73 ± 0.48, 0.57-1.0, 20.6 ± 4.8, or, measured from level of point of attachment of anal membrane 0.42 ± 0.067, 0.12-0.77, 51.0 ± 14.1: it is evident that the extension of the membrane behind the ray exhibits such great variability (V=51) that a caudal peduncle length measurement involving its point of attachment is of no taxonomic value. Snout in head 3.87 ± 0.16, 3.3-5.2, 13.0 ± 3.0: the presence of the upper extreme value (5.24), provided by the smallest individual, raises the coefficient to a magnitude that may be regarded as uncharacteristically high; the statistics with this fish omitted becoming 3.72 ± 0.074, 3.3-4.1, 6.0 ± 1.4. Eye in soft interorbital 5.05 ± 0.19, 4.3-6.3, 11.8 ± 2.7.

For the ratios considered the distribution in our material of the variates is satisfactorily symmetrical, the number of entries within one standard deviation on either side of the mean for block of nine ratios noted above being 6, 7, 6, 8, 7, 7, 5, 6, 6, respectively (in normal distribution, $N = \infty$, expected 7), and for the ratios of the last paragraph 7, 6, 8, 6 (expected value for third entry 6).

Comparison of proportions

Values of proportions noted above as being found in our material and in that of Briggs are in general in satisfactory agreement with those reported earlier by Waite (1906, p.204).

However, of the two statements on proportion contained in the original description (Ramsay 1883, p.148), one 'the length of the head is $3^1/_5$ in the total length, without caudal', presents difficulty, our range being 2.3-2.7, Briggs' range 2.3-2.5, and Waite's single value 2.7; while our range for head in *Lt* is 2.8-3.2, mean 3.05 ± 0.047, and an approximate reading from Waite's figure is 3.2. Formally, for our *Ls* values and Ramsay's 3.2 d/σ' (σ', with n-1 degrees of freedom: elsewhere in this paper , with n degrees of freedom), is 4.87, for our *Lt* values and 3.2 it is 0.96. It thus seems highly probable that though in the original description length without caudal is expressly stated, the datum $3^1/_5$ actually specifies head in total length, including caudal.

Relative growth

In a series as short as the present one, clear indications of possible systematic variation of body proportions with overall length are in general scarcely to be looked for. However, the ratio snout (Briggsian) in head exhibits significant correlation with *Ls*, with r—0.677 (z— 0.823), t 2.601*, a slightly better correlation being found when snout is measured between parallels, r—0.748, (z 0.968), t = 3.188*.

Coloration

The type (spirit specimen) was described as rich salmon red, reticulated on back and sides with lines of yellowish. Waite reported the colour of all his examples (preserved in formalin) as uniform yellow. The first account of the life colours was

given in Part III of this series (1936, p.123); quoted by Briggs (1955, p.13).

Note on locality

Waite specified his material as 'Three specimens from near Launceston, Tasmania, and three from Ulverstone, Tasmania, forwarded by the Curator of the [Queen] Victoria Museum, Launceston, in 1903', and observed 'one of the former batch is very possibly the type of the species'. Launceston is 60-67 km from the sea; and, as far as is known, *Creocele cardinalis* is marine. The suggestion is here advanced that at that time Launceston might well present itself as a natural point of reference, and that 'from near Launceston' means from (or from near) George Town, situated near the mouth of the Tamar (habitat of type, 'near George Town, Tasmania').

Brain

In several specimens the dorsum of the brain is discernible through the skull roof. As far as can be determined by simple observation, without dissection, it exhibits the following features. The best-developed portion is the midbrain: the optic lobes, closely apposed throughout, are subelliptical, a little longer than wide. The cerebral hemispheres are ovoid, somewhat shorter, and distinctly narrower, than the optic lobes, their area 0.7-0.8 that of the latter. The cerebellum is ovoid, its area subequal to that of the two hemispheres, nearly twice as long as wide, its greatest width at its anterior one-third: it overlies the median four-fifths of the anterior width of the medulla oblongata, which is three times, or more, as long as wide, and which presents a median fissure in the middle half of its length. At the anterior border of the cerebral hemispheres there appear to be two small extensions that may represent olfactory lobes or enlarged bases of the auditory nerves: however, the presence here of a transverse skeletal element makes accurate observation impracticable.

The total width of the brain is equal to about half the shortest distance between the supraorbital ridges. A transverse bar (possibly marking the junction of nasals and frontals) crosses the hemispheres at the front, at the level of the hind one-third of the orbit; the level of the posterior orbital rim being at, or slightly behind, the middle of the optic lobes. Differences in these features in the brain of *Cochleaceps spatula* are noted in the account of that species below.

The general disposition of the parts is much as in the brain of the Pike, as figured by Huxley (1871) — minor differences of shape and proportion being the more rounded form of the cerebral hemispheres and of the optic lobes, the less linguiform outline of the cerebellum, and the relatively smaller size of the optic lobes in the present species.

In one individual the presence of some of the cranial nerves can be observed, the olfactory, the optic and the trigeminal being clearly traceable.

Subfamily DIPLOCREPINAE

Genus *ASPASMOGASTER* Waite, 1907

Crepidogaster Günther, 1861, *Cat. Fish. Brit. Mus.*, 3, p.507. Logotype, *Crepidogaster tasmaniensis* Günther. Preocc. by *Crepidogaster* Boheman, 1848 (Coleoptera).

Aspasmogaster Waite, 1907, *Rec. Aust. Mus.*, 6 (4), p.315. *Nom. nov. pro Crepidogaster* Günther. Virtual logotype, *Crepidogaster tasmaniensis* Günther.

Volgiolus Whitley, 1935, *Aust. Mus. Mag.*, 5 (9), text fig. on p.292: advanced earlier, 1931, *Aust. Zool.* 6 (4), p.325, as subgenus of *Diplocrepis* Günther, 1861, with type species *Diplocrepis costatus* Ogilby, 1885. Briggs (1955), in list of literature cities for 1935 reference vol. 9, in error for vol. 5.

Aspasmogaster tasmaniensis (Günther, 1861)

Crepidogaster tasmaniensis Günther, 1861, *Cat. Fish. Brit. Mus.*, 3, p.507. Type locality: Tasmania.

Aspasmogaster tasmaniensis Waite, 1921, *Rec. S. Aust. Mus.*, 2, (1), p.179. *Id.* McCulloch, 1929, *Mem. Aust. Mus.*, 5 (3), p.359. *Id.* Scott, 1936, *Pap. Proc. R. Soc. Tasm.* (1935), p.120, fig. 2.

Diplocrepis costatus Ogilby, 1885, *Abstr. Proc. Linn. Soc. N.S.W.*, p.iii (*nom. nud.*); 1885, *Proc. Linn. Soc. N.S.W.*, 10 (2), p.270. Type locality: Shark Reef, Port Jackson. *Id.* McCulloch, 1929, *Mem. Aust. Mus.*, 5 (3), p.360 (part; New Caledonia record excluded).

Volgiolus costatus Whitley, 1935, *Aust. Mus. Mag.*, 5 (9), fig on p.292. *Id.* Scott, 1936, *Pap. Proc. R. Soc. Tasm.* (1935), pp.119, 120.

Volgiolus interorbitalis Whitley, 1943, *Proc. Linn. Soc. N.S.W.*, 68, (4), p.141. Type locality: Albany, King George's Sound, Western Australia.

?Aspasmogaster patella Scott, 1954, *Rec. S. Aust. Mus.*, 11 (5), p.111. Type locality: Kingston Park, South Australia.

Appearance in Tasmanian lists

This species appears as *Crepidogaster tasmaniensis* in Johnston's first list (1883, p.123); omitted from his second list (1891); reappears in Lord (1923, p.71), Lord & Scott (1924, pp.14 and 89), Lord (1927, p.16) as *Aspasmogaster tasmaniensis*.

Synonymy

The action of Briggs in relegating to the synonymy of the present species *Diplocrepis costatus* Ogilby and *Volgiolus interorbitalis*, to type material of both of which he had access, is followed here; it should be noted, however, that in his Australian name-list, Whitley (1964, p.54) retained the latter species.

As regards *A. patella*, also treated by Briggs as a synonym, Scott himself apparently reached the same position, as later, in his South Australian catalogue (1962), he listed only *A. tasmaniensis*, illustrating his account with his original figure (1954, fig. 3) of *A. patella*. However, there is a possibility, apparently not envisaged by Briggs, that Scott's material may be referable to *A. liorhynchus* Briggs, 1955. Of this species, first described in the monograph, it is stated, 'Although closely related to *A. tasmaniensis*, in other respects, it does not possess the characteristic fold of tissue across the tip of the snout'; the anus is located 'either half way between rear margin of disc and origin of anal fin or else closer to the latter' (*cf. A. tasmaniensis* closer to anal origin: in three Tasmanian examples described in Part III (1936, p.121) distance from disc is 1.3-1.6 distance from anal, in three examples noted below 1.92, 1.80, 1.49 ; fewer pectoral rays, 21-23 (*cf.* 24-27); eye somewhat smaller, mean value 4.3, *cf.* 4.0, in head. Scott's account of his *A. patella* does not mention, nor does his figure give any indication of, any accessory postlabial fold; vent is reported as midway between disc and anal; pectoral 18-19; eye 5.5 in head. A possible difference occurs also in the anterior dorsal profile, described by Scott as 'strongly convex from beginning [=end] of head to tip of snout', and so shown in his figure: in Tasmanian material of *A. tasmaniensis* the dorsal profile in advance of middle of eye is overall concave, much as depicted in a figure of a virtual topotype (Scott, 1936, fig. 2). Unfortunately no help is obtainable from colour pattern reported as including 21 cross bars in *A. patella*, instead of 14 in *A. tasmaniensis*, but not being recorded in *A. liorhynchus*.

It may be observed in passing that the figure of *Diplocrepis costatus* by Waite (1904, pl. 24, fig. 4) — a species included by him in his South Australian catalogue (1921), but later dropped from that State's list by Scott (1962), also by Scott *et al.* (1974) — shows the preorbital portion of the head with an evenly convex profile.

TABLE 4

Creocele cardinalis (Ramsay, 1882), 10 specimens, *Cochleoceps spatula* (Günther, 1861), 7 specimens, *Aspasmogaster tasmaniensis* (Günther, 1861), 3 specimens. Dimensions : first line, standard length, in mm, other lines as permillages of standard length. Measurements made, in general, between parallels : last six entries record measurements taken in accordance with the procedures of Briggs (1955). Locality data in text.

	Creocele cardinalis		*Cochleoceps spatula*		*Aspasmogaster tasmaniensis*	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
Standard length	25.0-50.3	39.3 ± 2.41	15.5-19.5	17.3 ± 0.542	35.2-65.6	53.6 ± 7.62
Total length	1188-1249	1220.8 ± 6.53	1160-1233	1197.0 ± 9.12	1152-1173	1164.0 ± 5.12
length to dorsal origin	720-784	761.4 ± 6.94	810-851	829.1 ± 4.45	716-775	747.7 ± 14.0
Length to dorsal termination, ray	890-958	917.1 ± 5.51	862-928	898.7 ± 7.77	935-943	939.7 ± 1.94
Length to dorsal termination, membrane	932-944	961.0 ± 5.88	—	—	988-997	992.3 ± 2.16
Length to anal origin	777-852	818.4 ± 6.21	815-856	835.4 ± 4.48	739-764	754.3 ± 6.33
Length to anal termination, ray	890-939	922.2 ± 4.15	894-923	906.4 ± 4.27	929-932	930.3 ± 0.745
Length to anal termination, membrane	917-987	952.5 ± 5.84	—	—	957-986	973.7 ± 7.06
Length to pectoral origin	286-356	313.2 ± 6.61	260-317	292.4 ± 7.20	322-366	340.3 ± 10.8
Length of pectoral	201-240	214.8 ± 10.6	173-212	188.1 ± 4.24	180-217	200.7 ± 8.90
Length to ventral origin, ray	194-282	243.1 ± 7.57	250-306	273.1 ± 6.82	281-307	290.7 ± 6.71
Length to front of disc	173-234	205.9 ± 5.28	216-272	241.0 ± 7.31	214-278	244.7 ± 12.9
Length to junction of two elements of disc	367-393	377.9 ± 3.10	323-367	349.3 ± 4.95	342-391	360.0 ± 7.10
Length to end of disc	504.576	533.0 ± 5.46	450-494	474.7 ± 5.66	511-540	525.7 ± 6.84
Length to vent, middle	616-690	650.2 ± 5.59	635-733	667.9 ± 10.9	633-676	659.7 ± 11.0
Head	373-440	420.6 ± 7.01	308-361	332.9 ± 5.78	381-406	392.0 ± 9.54
Snout, between parallels	84-133	106.8 ± 3.85	81-116	100.0 ± 4.97	106-114	109.7 ± 1.91
Eye	59-76	65.8 ± 1.82	56-91	75.1 ± 4.22	75-85	81.3 ± 2.69
Interorbital, soft	120-144	130.8 ± 2.36	67-90	80.1 ± 3.38	53-114	102.0 ± 5.10
Depth at front of eyes	100-136	118.6 ± 3.00	83-105	93.4 ± 2.57	76-85	82.0 ± 2.45
Depth at back of eyes	124-184	155.6 ± 5.88	108-142	118.7 ± 4.58	117-120	118.7 ± 0.723
Depth at opercular border	120-274	196.9 ± 12.3	132-167	155.1 ± 4.73	139-159	149.3 ± 4.74
Depth at vent	123-203	163.9 ± 6.77	117-151	133.1 ± 4.90	148-150	149.0 ± 0.745
Depth of caudal peduncle	76-110	102.2 ± 2.96	56-72	63.1 ± 2.24	92-96	94.0 ± 0.943
Maximum depth of head	140-228	194.2 ± 8.47	105-156	126.3 ± 6.11	131-165	148.7 ± 8.03
Maximum depth of body	167-254	207.2 ± 8.71	116-174	142.7 ± 8.04	160-170	166.3 ± 2.60
Width at front of eyes	197-253	230.9 ± 5.52	132-191	162.1 ± 7.52	115-130	124.3 ± 3.84
Width at back of eyes	295-415	327.2 ± 10.1	189-259	221.1 ± 9.81	204-222	215.0 ± 4.67
Width at opercular border	291-395	320.5 ± 9.80	247-269	256.0 ± 3.06	199-250	225.7 ± 17.3
Width at vent	99-163	142.6 ± 8.16	106-146	128.0 ± 5.95	106-129	120.0 ± 5.79
Width of posterior element of disc	237-306	261.8 ± 7.86	162-187	175.0 ± 3.74	170-217	196.3 ± 11.3
Maximum width of head	325-404	357.6 ± 4.44	247-278	260.6 ± 3.74	243-267	256.3 ± 5.76
Maximum width of body	246-304	277.9 ± 5.72	250-281	265.3 ± 4.04	199-250	225.7 ± 17.3
Dorsal-caudal	217-294	273.3 ± 6.65	154-190	175.3 ± 4.02	250-284	267.0 ± 8.01
Postdorsal-caudal	102-152	120.5 ± 4.91	80-123	102.6 ± 5.69	83-91	87.3 ± 1.91
Length of caudal peduncle	79-116	99.2 ± 3.44	65-110	95.6 ± 5.82	80-108	92.0 ± 6.80
Chin-disc	167-224	197.4 ± 5.46	206-269	237.1 ± 7.91	205-277	233.7 ± 18.0
Snout	120-149	135.9 ± 2.63	106-126	113.0 ± 2.92	119-131	123.3 ± 3.14
Interorbital	92-119	105.9 ± 2.62	51-66	58.4 ± 2.16	57-67	62.0 ± 2.36

Material

Three examples: (*a*) *Ls* 35.2, *Lt* 41.3, (*b*) 59.9, 69.9, (*c*) 65.8, 75.8 all collected at Greens Beach, northern Tasmania, by Mr R.H. Green, Queen Victoria Museum; (*a*) 11 January 1962, Q.V.M. Reg.No.1962/5/3, (*b*), (*c*) 10 January 1964, Q.V.M. Reg.No.1972/5/190.

Meristic data

Entries in parentheses are ranges reported for the species. D.8,9,9,(8-10); A.7,8,8, (7-9 Briggs; 6 Ramsay); P. (left/right) 25/25, 24/24, 25/25 (24-27 Briggs; 22 Ramsay; 18-19 Scott); V.4 (Scott i,4); C.11,11,11 (11-12 Briggs; 13-14 Scott, possibly including some minor rays).

Dimensions

Table 4 sets out standard lengths and the same set of dimensions expressed as *TLs* for this species as are there recorded for *Creocele cardinalis* and *Cochleoceps spatula*.

Proportions

Values for our material for the nine standard ratios of specific diagnoses in Briggs' monograph, followed, after a colon, by that author's figures, arithmetic mean, range in parentheses for his 9 examples. Postdorsal-caudal distance in dorsal length 2.03, 2.02, 2.02: 1.7 (1.5-1.8). Depth in *Ls* 5.86, 5.93, 6.27: 6.0 (5.7-6.5). Depth of caudal peduncle in its (Briggsian) length 0.85, 0.96, 1.13: 1.2 (1.2-1.3); with length measured between parallels, from base of last ray 0.70, 0.76, 0.72, from end of anal membrane 0.09, 0.24, 0.14. Length of head in *Ls* 2.46, 2.57, 2.62; 2.7 (2.6-2.8). Width of head in *Ls* 3.76, 3.74, 4.11: 3.9 (3.8-4.1). Snout (Briggsian) in head 3.11, 3.28, 3.18: 3.6 (3.5-3.8); with length measured between parallels 3.58, 3.58, 3.60. Eye in bony interorbital 0.67, 0.80, 0.84; 0.7 (0.6-0.7); in soft interorbital 1.33, 1.18, 1.24. Eye in head 4.77, 4.66, 5.12: 4.0 (3.2-4.4). Length of disc in head 3.45, 3.20, 3.72: 3.5 (3.4-3.7).

Some additional proportions of these three examples having diagnostic significance are here given, followed, where appropriate, by the range for the three 1936 Tasmanian specimens (*Ls* 30.8, 46, 46): a single value or a range from a conflation of values from the date of Ogilby (*Diplocrepis costatus*), Whitley (*Volgiolus interorbitalis*), Scott (*Volgiolus patella*) is added in parentheses where the information is available.

Head in *Lt* 2.89, 3.00, 3.02, 2.9-3.1 (2.9-3.6). Width of head in *Lt* 4.54, 4.37, 4.74, 4.14 (4.8). Depth of body in *Lt* 6.88, 6.92, 7.22, 6.2-6.8 (6.4). Depth at vent in *Lt* 7.64, 7.77, 7.73 (8). Depth of caudal peduncle in head 4.33, 4.24, 3.98 (3.82). Length to vent in *Lt* 1.75, 1.72, 1.74(1.82). Length of disc in *Lt* 4.49, 3.74, 4.23 (5.0). Width of disc in *Lt* 6.88, 5.78, 5.38 (5.8). Dorsal base in head, base without terminal membrane 2.04, 2.33, 2.09, with membrane 1.44, 1.71, 1.56,(1.5-1.6). Anal base in dorsal base, bases without membranes 1.04, 0.97, 1.09, with membranes 1.32, 1.04, 1.06 (1.2). Pectoral in head, whole fin 1.88, 2.16, 1.86, measured from base of median rays 3.04, 2.91, 2.82, (2.6-2.9). Caudal in *Lt* 6.77, 5.99, 6.58, 5.9-7.6 (*ca* 6-6.4).

Total and standard lengths

Reported lengths include: *Ls*, type of *A. costatus* 46.7 (20.5 lines), types of *A. interorbitalis* 20, 21, six Tasmanian examples, 22.5, 30.8, 46, 46, 59.9, 65.8 (the last exceeding the maximum known size as recorded by Briggs, 62.0): *Lt*, *A. patella* 56, 57, 64 (type), 72, six Tasmanian examples 25.7, 36, 53, 53, 69.9, 75.8.

Coloration

Accounts of coloration show some variation. In life 'uniform pink, appearing almost transparent when removed from the water' (Ogilby); a similar description was given by Waite (1923, p.207). Part III (1936, p.121) recorded the collector's note 'Dark green with brown markings when found; but when placed in a white net turned

light green', and added that, examined shortly after fixation in formalin, the two specimens each bore some fourteen dark bars. In alcohol, the colour of *A. interorbitalis* was 'yellowish brown in the holotype, blotched with carmine in the paratype; sides with a few spaced minute brown speckles. Eyes blue'; while the holotype of *A. patella* was 'yellow ochre, with twenty-one reddish-brown bars completely encircling the body'. In a first record of *Diplocropis costatus* from New Caledonia Whitley (1927, p.304) noted the colour in spirits as dull yellow, ' a dusky ill-defined cross bar across the nape, another over the pectoral, a third between the tips of the pectorals and the origin of the dorsal, and traces of another between dorsal and anal. Top of head dusky, interorbital lighter. Vertical fins with minute punctulations, with lighter spaces distally.'

The following notes were made on a small individual, *Ls* 22.5, *Lt* 25.7, shortly after its collection by Mr R.H. Green, Queen Victoria Museum, at Greens Beach, northern Tasmania, 16 April 1975.

Dorsal surface uniform fairly deep green, vermiculated with (apparently not superficial) white; indications of red bars as follows, front of eye, back of eye, just before end of head, slightly in advance of disc, about at vent, across dorsal, and (faint, slender) at hypural; some obscure smaller red spots on dorsum of snout. Lateral surface concolorous with dorsal; the mesial two-thirds or so with a red flush extending from head about to below middle of dorsal, where it tends to develop some wavy lines that extend back on to peduncle; whitish vermiculations traceable only on head; a pale reddish patch on dorsal base; red markings on head comprising one subtriangular area extending from lower two-thirds of orbit forward, somewhat downward, for half length of snout, its apex reaching ventral profile, and a similar-sized, but more intense, triangle extending backward, somewhat downward, from orbit; below it three red dots, the upper two contiguous with it; running from eye almost to ventral profile three equally spaced markings, the front and back ones forwardly concave, the middle one straight, vertical, obscurely double. Ventral surface lighter green; on under surface of snout half a dozen reddish spots, followed on each side, at level of eyes, by three short, equally spaced forwardly concave arcs, those on right continuous lines, those on left series of dots, the two sets together occupying about two-thirds width of head here; posterior half of disc with two prominent dark green spots side by side near the middle, and with hind border darker than rest; one red spot just behind anal base and another midway between this and hypural.

Dorsal and anal virtually colourless, in parts slightly greenish basally. Pectoral colourless. Caudal in general green, about concolorous with peduncle; marked with three complete arcs of about 8 (basal), 6, 6 red spots, and one less perfect arc.

Ridging

Ogilby based his second binomen on the presence in his type of 'about 10 strongly marked vertical ridges on each side, caused by the contraction of the muscles after death, but not present in the living fish', noting that this peculiarity is shared by the New Zealand *Diplocrepis puniceus* (Richardson, 1846). These ridges (which presumably demarcate myomeres) are conspicuous features in the Greens Beach specimens, anteriorly, where best developed, taking the form of complete or nearly complete, about equally spaced parallel rings, their height in some instances almost equal to the space between their bases. Ogilby noted 'about 10': we find 10-11 between back of head and vent, 4 to dorsal origin, about 12 between this and hypural, much less evident in this last region, here appearing chiefly as short vertically running swellings closely spaced along the fin bases.

Genus *COCHLEOCEPS* Whitley, 1934

Cochleoceps Whitley, 1943, *Proc. Linn. Soc. N.S.W.*, 62 (4), p.141. Orthotype, *Cochleoceps spatula* (Günther, 1861)

Cochleoceps spatula (Günther, 1861)

Crepidogaster spatula Günther, 1862, *Cat. Fish. Brit. Mus.*, 3, p.508. Type locality: Swan River, Western Australia.
Aspasmogaster spatula Waite, 1921, *Rec. S. Aust. Mus.*, 2 (1), p.179, fig. 296.
Cochleoceps spatula Whitley, 1943, *Proc. Linn. Soc. N.S.W.*, 63 (4), p.141.

Tasmanian occurrence

Cochleoceps spatula is not included in any published Tasmanian list, and its occurrence in this State was not known to the writer when assembling some notes on the local species (1936). The first record for Tasmania, was provided by Whitley (1954, p.29), who noted one example from Wineglass Bay and one from Oyster Bay, both on the East Coast. Briggs' material included an Australian Museum specimen from Wineglass Bay (his paper citing a registration number differing from that given by Whitley).

The Queen Victoria Museum collection contains 9 examples, all small, collected, on five occasions, at Greens Beach, northern Tasmania by Mr R.H. Green. The material, with samples listed chronologically, but with individuals lettered in sequence of increasing *Ls*, comprises: (*d*) *Ls* 16.0, *Lt* 19.5 (*h*) 18.9, 22.9, 11 November 1963, Q.V.M. Reg. No. 1972/5/195; (*b*) 14.5, 17.5, 5 April 1965, Q.V.M. Reg. No. 1972/5/374; (*a*) 12.9, 16.1, 11 September 1965, Reg. No. 1972/5/194; (*e*) 15.5, 18.3, (*e*) 16.2, 18.8, (*f*) 16.7, 20.6, (*i*) 19.5, 22.9, 19 December 1965, Reg. No. 1972/5/422; (*g*) 18.0, 21.6, 14 November 1966, Reg. No. 1972/5/360.

Dimensions

Table 4 sets out standard lengths and other dimensions.

Proportions

Values have been found for the same set of proportions as that recorded above for *Creocele cardinalis* and these are here presented in the same style. Greatest depth in *Ls* 7.16 ± 0.40, 5.8-8.6, 14.7 ± 4.0: 5.4, 4.9-6.0. Depth of caudal peduncle in its (Briggsian) length (1.58± 0.10, 1.1-2.0, 17.4 ± 4.8: 1.5, 1.3-1.7. Length of head in *Ls* 3.01 ± 0.54, 2.8-2.3, 4.7 ± 1.3: 2.4, 2.3-2.6. Width of head in *Ls* 3.90 ± 0.038, 3.7-4.1, 2.6 ± 0.7: 3.3, 2.8-3.8. Snout (Briggsian) in head 2.95 ± 0.055, 2.8-3.2, 5.0 ± 1.3: 3.1, 2.9-3.9. Eye in bony (Briggsian) interorbital 0.79 ± 0.031, 0.7-1.0, 10.4 ± 2.8: 1.0, 0.7-1.2. Eye in head 4.57 ± 0.27, 3.9-6.1, 15.4 ± 4.1: 4.4, 3.8-5.0. Post-oral-caudal distance in dorsal length 0.44 ± 0.33, 0.3-0.6, 25.1 ± 6.7: 0.6, 0.6-0.7. Disc length in *Ls* 4.23 ± 0.98, 3.6-4.5, 6.1 ± 1.6: 3.3, 3.2-3.6. Some of the difference between the two sets of results is perhaps attributable to probable difference of size of fish in the samples.

Two ratios with measurements between parallels are noted for comparison with comparable data from other sources. Depth of caudal peduncle in its length 1.51 ± 0.11, 1.19-1.9, 19.2 ± 5.1; snout in head 3.35 ± 0.13, 3.0-4.1, 10.5 ±2.8. Eye in soft interorbital is 1.10 ± 0.070, 0.9-1.5, 16.8 ± 4.6.

Coloration

The entry under this heading in Briggs' monograph reads: 'No coloration remained in the alcohol specimens available for examination'. Waite (1923, p.206) reported the colour to be yellow with the upper half ornamented with crowded carmine spots.

The following account is based on two examples, *Ls* 18.2, 19.0, *Lt* 21.0, 23.6, collected by Mr R.H. Green, Queen Victoria Museum, at Greens Beach, northern Tasmania,

16 April 1975.

Ground colour of whole of lateral and dorsal surfaces almost uniform lettuce green (paler than in the two examples already noted, of *Aspasmogaster tasmaniensis*, taken at the same time). Virtually whole dorsum of head with very small rounded red spots (approaching carmine), abundantly and closely set everywhere, except on part of the posterolateral regions where they are noticeably fewer. Spots continued from back of head along mesial half, or a little more, of whole length of body: in one specimen distinct aggregations of some 6-12 spots (in anterior three sets larger than other spots), tending to form gross red areas as follows, a postorbital pair, distance between them subequal to their distance from eye; one, median, on occiput, behind eyes by length of snout; one, median, just in advance of level of hind border of disc, its distance behind last mentioned subequal to distance of latter behind eyes; two, median, about equally spaced, hinder about at level of vent; one, median, small, somewhat indistinct, on caudal peduncle: in other specimen postorbital marking single, not paired; other spot-groups somewhat less developed. Reddish brown streak running forward to tip of snout, back to end of head, continuing for distance about equal to length of snout on trunk: these lines on head just visible from above, outlining it in brown. Lateral surface of body unmarked save for anterior brown streak just mentioned, and a few small reddish spots on tail. Ventral surface very pale green, approaching white on disc and on throat; immaculate. All fins pale greenish; in one individual some indication of probable former occurrence of a few small reddish or reddish brown spots.

Brain

The dorsal aspect of the brain is more or less clearly traceable in all our specimens. It differs from that of *Creocele cardinalis*, described above, as follows: total width, relative to interorbital, noticeably greater, equal to at least four-fifths of interval between supraorbital ridges; whole brain set further forward, relative to orbit, anterior border of cerebral hemispheres being in advance of middle of orbit, and level of posterior orbital rim crossing optic lobe in anterior one-third of latter.

Comparison of species measurements

Comparisons have been made of the means in the above samples of the three Tasmanian species of the nine ratios reported in species diagnoses in the monograph by Briggs. The results are set out in the first nine lines of table 5.

A further comparison, by pairs of species, involving the means of *TLs* lengths to certain important morphological landmarks along the general anteroposterior axis provides some additional useful criteria for the separation of the local clingfishes. The data are given in the last eight lines of table 5.

It will be noted that, in the great majority (80%) of the entries in table 5, probability either, on the one hand, lies well below the level of formal statistical significance (P 0.05) or, on the other hand, reached P 0.001, or better. It would be of interest to ascertain whether this combination of virtual identity and marked disparity of mean *TLs* value for these dimensions characterizes only the present small group of species, or whether differences between species, where they occur, are generally trenchant. The lower measures of significance exhibited by length to front of disc as compared with length to back of disc are accounted for by greater variability of the latter dimension in all species, the relevant coefficients of variation being 8.2, 3.2 (*Creocele cardinalis*), 10.7, 3.2 (*Cochleoceps spatula*), 8.1, 2.3 (*Aspasmogaster tasmaniensis*).

In view of the taxonomic value of the three-term system, relative locations of hind end of disc, vent, anal origin, considerable importance is attached to the virtually constant mean permillage length to vent found in these species — with the middle value, that for *Aspasmogaster tasmaniensis* (66) taken as a norm, the greatest value

TABLE 5

Creocele cardinalis (Ramsay, 1882, 10 specimens, *Cochleoceps spatula* (Günther, 1861), 7 specimens, and *Aspasmogaster tasmaniensis* (Günther, 1861), 3 specimens. Value of *t*, with probability levels of 0.05, 0.01, 0.001 denoted by one, two, three asterisks, respectively, for difference of means, by pairs of species, first, of the ratios reported in species diagnoses by Briggs (1955) (first 9 lines), secondly, of lengths, as permillages of standard length to certain points along anteroposterior axis of fish (last 8 lines).

Ratio or Length (*TLs*) to specified point	*C. cardinalis* v *C. spatula*		*C. cardinalis* v *A. tasmaniensis*		*C.C. spatula* v *A. tasmaniensis*	
Depth in standard length	***	5.046	*	2.602	-	1.668
Depth of caudal peduncle in its length	***	5.960	-	0.062	*	3.283
Length of head in standard length	***	21.632	-	0.627	***	17.160
Width of head in standard length	***	11.034	***	9.843	-	0.266
Snout in head	-	0.024	**	3.754	*	2.411
Eye in (bony) interorbital	***	6.765	***	4.479	-	0.421
Eye in head	***	4.897	***	11.822	-	0.605
Postdorsal-caudal in dorsal base	***	10.045	***	7.797	***	22.391
Length of disc in standard length	***	10.159	*	2.907	**	4.031
End of head	***	6.974	-	0.759	***	5.474
Front of disc	**	3.754	*	2.741	-	0.220
Back of disc	***	6.791	-	0.677	***	4.625
Vent (middle)	-	1.475	-	0.755	-	0.934
Origin of dorsal	***	8.527	-	0.713	***	6.371
Origin of anal	-	1.916	***	4.945	***	7.032
End of dorsal	-	2.043	-	1.865	**	4.702
End of anal	-	1.815	-	0.985	*	3.175

(*Cochleoceps spatula*) is in excess of it by only 1.2%, the least (*Creocele cardinalis*) is in deficit of it by only 1.4%. For length to end of disc the highest value (*Creocele cardinalis*) and the lowest (*Cochleoceps spatula*) are 1.5% above, 9.6% below the middle value (*Aspasmogaster tasmaniensis*, 525). For length to anal origin the highest value (*Cochleoceps spatula*) and the lowest (*Aspasmogaster tasmaniensis*) are 2.1% above and 7.8% below the middle value (*Creocele cardinalis*, 818).

The apparent pattern, noted above, of a combination, for difference of means of species by pairs, of high with low degree of significance, with no or few intermediate values, is met with also in some variates other than 'length to' permillage measurements. Three examples may be cited. With species pairs in the sequence of table 5, *t* values for width of posterior element of disc are 10.481***, 4.758***, 1.987; for soft interorbital 11.797***, 3.343**, 2.050; for width at back of eyes 6.621***, 5.564***, 0.328.

In seeking to interpret any of the above results it is to be borne in mind that the data relate only to the present samples and that these are small. Further, the size of our specimens differs considerably both within and between species (standard length in *Creocele cardinalis* 25.0-50.3, $\bar{x}$ 39.27 ± 2.41, *Cochleoceps spatula* 15.5-19.5, $\bar{x}$ 17.26 ± 0.54, *Aspasmogaster tasmaniensis* 35.2-65.8, $\bar{x}$ 56.63 ± 7.73), and we are at present without useful knowledge of possible relative growth in any of the regions involved. On the other hand, the high *t* values for some measurements and some proportions clearly reflect gross morphometric differences and are of immediate taxonomic relevance.

Family GOBIIDAE

Only three gobies are credited to Tasmania in the Australian Check-list (McCulloch, 1929): (*i*) *Nesogobius hinsbyi* (McCulloch & Ogilby, 1919) (*ex* Johnston MS), (*ii*) *Gobius tasmanicus* Whitley, 1929 (*ex* Johnston MS), (*iii*) *Gobius tamarensis* Johnston, 1883; all have Tasmania as type locality. The lists of Lord (1923, 1927) and of Lord & Scott (1924) included also (*iv*) *Gobius lateralis* Macleay, 1881 (Lord & Scott suggesting (*iii*) is probably identical with (*iv*)): (*iv*) is referred in the name-list of Whitley (1964) to *Favonigobius* Whitley, 1930.

In a survey of the Tasmanian gobiid fauna, as then known, made in this journal four decades ago (Scott 1935) accounts were given of (*i*) and (*iii*), the latter being figured (pl. IV, fig. 1) for the first time; it was considered likely (*ii*) was a synonym of (*iii*), and the possibility of (*iv*) appearing in the local list in error was explored. A new genus, *Tasmanogobius*, was instituted and a new species, *T. lordi*, was described and illustrated (text figs 1,2, pl. IV, fig. 2).

Additions to our list since 1935 comprise (*vi*) *Arenigobius bifrenatus* (Kner, 1869), first Tasmanian records by Olsen (1954), in stomach contents of juvenile *Galeorhinus australis* (Macleay 1881), and by Whitley (1954), with further local records by Olsen (1958), Scott (1963); (*vii*) *Stigmatogobius poicilosoma* (Kner, 1865), [so listed by Koumans (1953); variously recorded by Australian authors, *e.g.*, by McCulloch & Ogilby (1919) and by McCulloch (1929) as *Mugilogobius galwayi* McCulloch & Waite, 1918, by Scott (1962) as *Ellogobius olorum* (Sauvage, 1880), by Whitley (1964) as *Lizagobius olorum* (Sauvage, 1880), by Scott *et al.* (1974) as *Lizagobius galwayi* (McCulloch & Waite, 1918)], first Tasmanian record in Part XI, from The Arm, George Bay, east coast; (viii) *Callogobius mucosus* (Günther, 1871) [appears in McCulloch & Ogilby as *Callobius hasseltii* Bleeker 1851, with *C. hasseltii* var. *mucosus* Günther as the form in southern Australia; Whitley's name-list recognizes both Bleeker's species and Gunther's; Scott and Scott *et al.* treat the South Australian records as *C. mucosus*], first Tasmanian record in Part XIII, as *C. hasseltii*, based on three examples from Greens Beach, north coast, where it has since been taken in abundance.

Keys to species on our list at the time were given in the review in 1935 and in Part XI (1963) — from species (*i*), (*ii*), (*iii*), covered by the later key, (*viii*) is separable at sight by its possession of prominent raised lines of papillae on head and body.

The Tasmanian gobiid fauna is richer than the present census would indicate — on several occasions unrecorded, and possibly undescribed, species have come under the writer's notice.

Genus *ARENIGOBIUS* Whitley, 1930

Arenigobius Whitley, 1939, *Aust. Zool.*, 6 (2), p.122. Orthotype, *Gobius bifrenatus* Kner.

Arenigobius bifrenatus (Kner, 1865)

Gobius bifrenatus Kner, 1865, *Reise Novara Zool. Fische*, p.177, pl. 7, fig. 3.
Type locality: Sydney, New South Wales.
[*Gobius*] *bifrenatus* McCulloch & Ogilby, 1919, *Rec. Aust. Mus.*, 12 (10), p.242.
Arenigobius bifrenatus Olsen, 1954, *Aust. J.mar. Freshw. Res.*, 5 (3), p.359. *Id.* Whitley, 1954, Proc. R. Zool. Soc. N.S.W. (1952-3), p.29. *Id.* Scott, 1953; *Pap. Proc. R. Soc. Tasm.*, 97, p.24.

Status of genus

For remarks on the genus *Arenigobius* see below, under *Arenigobius tamarensis*.

Material

Three series were taken in the course of an ecological survey of the Tamar River, northern Tasmania, by the Queen Victoria Museum in March and April 1975. Sample (*A*) 70 specimens from one pool on a mud flat, Middle Arm, approximately 12 km from the river mouth, 5 March, Q.V.M. Reg. No. 1975/5/39 : (*B*) 49 specimens from York Town Rivulet, discharging into the Tamar some 14 km from its mouth, 4 April, Q.V.M. Reg. No. 1975/5/54: (*C*) 106 specimens from Anderson's Creek, entering the Tamar about 13 km from its mouth, 23 April, Q.V.M. Reg. No. 1975/5/64.

A morphometric analysis of sample A, and some observations on the coloration of fresh examples are made below.

Length distribution

Inspection of the distribution of standard length of the 70 individuals of the total sample (*A*) suggests the existence of two sub-populations, one (*a*) of 63 larger individuals, the other (*b*) of 7 smaller individuals. That the two subsamples are genuinely distinct appears probable: they are separated by 8 empty 1-mm cells (only 3 empty cells at lower end of distribution of larger subsample); the upper extreme value of (*b*) lies beyond $\bar{x} \pm 3s$ for (*a*); a test of the significance of the difference of the means yields $t = 9.303$ *** (for *Lt* $t = 7.611$***).

For (*A*), (*a*), (*b*) the *Ls* ranges, mm, are 27.2-83.0, 45.7-83.0, 27.2-36.1. Means are 58.7 ± 1.40, 61.6 ± 1.02, 32.5 ± 0.959; medians 59.4, 59.9, 33.3; standard deviations 11.7 ± 0.987, 8.12 ± 0.724, 2.54 ± 0.678; coefficients of variation 19.9 ± 1.7, 13.2 ± 1.2, 7.8 ± 2.1. The distribution is tolerably symmetrical in (*a*) and (*b*), naturally less so in (*A*); the number of entries within $\bar{x} \pm s$ being, respectively, 43, 4, 55 (*cf.*, for $\bar{x} \pm \sigma$, with $N = \infty$, 43, 5, 48): skewness, measured by $Sk = 3(\text{mean}-\text{median})/s$, + 0.350, − 0.980, − 0.170.

The *Ls* frequency distribution of the whole sample in 19 classes, 26.5-29.4...80.5-83.4, with values for (*b*) in parentheses, is (1), (2), (3), (1), 0, 0, 1, 1, 8, 8, 10, 10, 6, 7, 4, 2, 4, 1, 1.

TABLE 6

Arenigobius bifrenatus Kner, 1865. Specification of head, trunk, tail (to hypural), caudal fin, as permillages of standard length, in a Tasmanian population (*A*) of 70 individuals, *Ls* 27.2-83.0, $\bar{x}$ 58.7 ± 1.40, treated also as two subpopulations, (*a*) of 63 individuals, *Ls* 45.7-83.0, $\bar{x}$ 61.6 ± 1.02, (*b*) of 7 individuals, *Ls* 27.2-36.1, $\bar{x}$ 32.5 ± 0.96. In last line, 'expected' = frequency in normal distribution ($N = \infty$).

Statistic	Head			Trunk		
	(*A*)	(*a*)	(*b*)	(*A*)	(*a*)	(*b*)
N	70	63	7	70	63	7
Range	223-311	223-309	243-311	155-352	174-352	155-259
$\bar{x}$	269.7 ± 1.63	267.1 ± 1.23	292.6 ± 8.13	252.7 ± 3.61	256.3 ± 3.52	221.1 ± 11.76
Md	267	265	298	255.5	259	210
Mo;*h*=1(*f*)	275(5)	275(5)	-	259(4)	259(4)	-
s	13.64 ± 1.15	9.78 ± 0.871	21.51 ± 5.75	30.20 ± 2.55	27.94 ± 2.55	31.34 ± 8.38
V	5.1 ± 0.4	3.7 ± 0.3	7.4 ± 2.0	11.9 ± 1.2	10.9 ± 1.0	14.2 ± 3.9
Sk	+ 0.625	+ 0.646	− 0.757	− 0.274	−0.297	+ 1.067
Within $\bar{x} \pm s$ ('expected')	42(48)	36(43)	6(5)	56(48)	48(43)	5(5)

	Tail (to hypural)			Caudal fin		
	(*A*)	(*a*)	(*b*)	(*A*)	(*a*)	(*b*)
N	70	63	7	70	63	7
Range	411-540	411-533	434-540	232-590	241-590	232-360
$\bar{x}$	477.4 ± 3.10	476.4 ± 3.06	486.4 ± 14.10	346.0 ± 26.43	351.1 ± 23.10	300.6 ± 13.55
Md	475	475	493	333.5	338	308
Mo;*h*=1(*f*)	483(5)	483(5)	-	285,302,339(2)	285,339(2)	-
s	25.95 ± 2.19	24.30 ± 2.16	34.41 ± 9.74	70.75 ± 18.91	61.11 ± 16.33	35.94 ± 9.58
V	5.4 ± 0.5	5.1 ± 0.5	7.5 ± 2.0	20.4 ± 5.7	17.4 ± 4.8	11.9 ± 3.2
Sk	+ 0.279	+ 0.177	− 0.541	+ 0.177	+ 0.219	− 0.207
Within $\bar{x} \pm s$ ('expected')	52(48)	40(43)	4(5)	49(48)	42(43)	5(5)

growth cannot be determined from available data, though it may well do so : a general inspection of the two April series finds they show a marked tendency to fall into three size classes of *Ls* round about 25-35, 50-60, 70-75 mm.

Comparison of (*A*) with (*B*) and (*C*)

In (*A*), the sample examined above, the proportion of fish of large or moderate size is higher than in either (*B*) or (*C*), the precentages of specimens in the 50.5-53.4 class and higher classes of *Ls* 87, 26, 10, respectively, the means 58.7, 37.5, 34.6, the medians 59.4, 43.0, 31.5: the highest entry in (*A*) extends 7, 4 size-classes (h = 3 mm) beyond the highest in B, C, respectively.

The *Ls* frequency distribution of the York Town Rivulet sample in 16 classes, 14.5-17.4 ... 59.5-62.4, is 1, 0, 4, 5, 7, 5, 0, 0, 2, 7, 2, 2, 6, 2, 2, 2; that of the Anderson Creek sample in 18 classes, 17.5-20.4 ... 68.5-71.4, is 2, 6, 11, 18, 21, 13, 5, 4, 4, 8, 3, 4, 2, 2, 0, 2, 0, 1. They show indications of being trimodal, with modes at 26.5-29.4 (7 entries), 41.5-44.4 (7), 50.5-54.4 (6) and at 29.5-32.4 (21), 44.5-47.4 (8), 50.5-53.4 (4). The 7 individuals of subsample (*b*) of (*A*) with mean 32.5 might thus well be coeval with individuals in the 26.5-29.4 and 29.5-32.4 lowest modal classes of (*B*) and (*C*).

The *Ls* specifications of (*B*) are range 17.0- 62.0, $\bar{x}$ 37.5 ± 2.15, s 14.8-1.53, *V* 39.5±4.7 *Sk* − 1.17, entries within $\bar{x} - s$ 36 (expected 32); of *C* range 18.5-70.5, $\bar{x}$ 34.6 ± 1.02, s 10.5-0.722, *V* 30.4-2.3, *Sk* + 0.889, entries with $\bar{x} \pm s$ 74 (expected 73).

Relative growth

Lengths of head, trunk, tail (to hypural joint), caudal fin, as permillages of standard length, have been calculated for all specimens; the specifications of these dimensions in each of the three groups (*A*), (*a*), (*b*) are exhibited in table

As inspection of the table shows, the mean *TLs* value for head in (*b*) is greater than that in (*a*), *i.e.*, relative length of head decreases with increasing size of fish: the difference between the means is highly significant, t=5.477***. For the whole sample (*A*) the correlation of *TLs* head with *Ls* is r = − 0.357 (z = 0.373), t = 3.140***. In the case of the trunk the mean *TLs* value of (*b*) is less than that of (*a*), *i.e.*, relative length of trunk increases as fish grows: for difference of means t = 3.069**. The correlation for (*A*) is r = + 0.218 (z = 0.222), t not being formally significant (1.848) − it should be noted the range is very wide (155-352, the second of these values being outside $\bar{x} \pm 3s$; the next extreme entries are 174, 322). With three body regions recognized, head, trunk, tail (to hypural) − caudal fin considered separately, below − any significant variation with growth in relative proportion among these appears to be confined to head and trunk, the relative decrease in length of the former being more or less completely balanced by the relative increase in the length of the latter; the tail, with its *TLs* versus *Ls* r= − 0.0886 (z = 0.0888), t = 0.734, representing a virtually constant fraction of the length.

As an appendage, the caudal fin calls for separate consideration. From the data of table 6 it will be seen its relative length in the subsample of larger individuals (*a*) is about one-sixth as great again as in the subsample of smaller individuals (*b*): the difference of the means is significant at t = 2.115*; while the correlation of *TLs* length of fin and length of fish (*Ls*) in the whole sample (*A*) is r = + 0.488 (z = 0.533), t = 4.609***. As figured − Kner's original illustration reproduced in Scott *et al.* (1974, p.269) − this species has the caudal long and pointed, a feature regularly noted in local descriptions − *e.g.*, Castelnau (1873, p.47) (as synonymic *G. caudatus*), Macleay (1881, p.597), McCulloch & Ogilby (1919, p.242), Scott *et al.* In our sample the median backward extension of the fin (which may finally become filamentous) tends very generally to become more pronounced with age, a striking indication of this being the fact that a length of 400 or more *Tls* units is encountered in only 2 individuals in the lower half of the series (specimens in order of increasing *Ls*), but

characterizes 12 fish in the upper half. Since with ageing the relative size of caudal increases while that of head decreases, specification of one in terms of the other (*cf.* Macleay) is without diagnostic value unless supplemented by information on overall size of fish. In passing from (*b*) to (*a*) here, mean length of head suffers a decrease of 8.7%, while mean size of caudal shows an increase of 14.4%; in other terms, at the smaller size the caudal is barely longer than (1.03 times) the head, while at the larger size it is decidedly longer (1.34 times) — much greater differences of course being encountered in individuals.

Life colours

A good account of the coloration of a fresh New South Wales specimen 142 mm long has been given by McCulloch & Ogilby (1919, 243). The species is an ornate one. Detailed notes, made within an hour of capture, on several of our examples, of which a summary is given below, reveal a number of interesting differences in these Tasmanian fish, and also specify some markings not mentioned by McCulloch and Ogilby.

General colour of trunk and tail olivaceous, darker above; ventral surface in advance of vent buff, iridescent in lateral strip, behind vent olivaceous barely lighter than flank. Short bars and/or blotches (6-10, modally 8) just above ventral profile deep grey-black. Between and across main bars numerous slender downwardly and slightly backwardly oblique red-brown bars or pencil-like strokes; one series of a dozen or more swinging down from angle of operculum and running along flank to end at hypural about three times as far from dorsal profile as from ventral; a second series of up to a score originating shortly above first, running back higher up on flank to end at hypural about three times as far from ventral profile as from dorsal (these markings not recorded by McCulloch & Ogilby). Iridescent spots in two rows in front, becoming irregular in last one-third of length; each gross 'spot' being a group of two or three fairly closely approximated subcircular components; in one specimen spots pale green (darkening caudad), some behind these pale blue or blue-violet; in a second specimen some green, some blue (darker than in first specimen); in a third specimen violet.

General colour of head olivaceous. Three red-brown stripes running back from eye; one, widest, from about 7 o'clock (left side viewed), curving down on to pectoral base; one, from about 9 o'clock, sloping down on to flank, obscurely making contact there with line of lateral bars; one, from about 11 o'clock, swinging up on to dorsal surface, where right and left fellows approximate or coalesce, running back to origin of first dorsal; a short black stripe, from near 7 o'clock, passing downwards and forwards towards lip. Lips dark olive; upper lip with dark superior border. Pupil black; iris mostly silvery white but with a large olive lunule covering upper one-fourth.

Second dorsal fin with membrane yellow, brighter above well-defined red stripe across fin at about one-third of its height; rays in general more or less colourless, but with reddish or pinkish flush towards tip. First dorsal similar to second but with slightly stronger colour. Pectoral clear translucent yellow ochre, a trifle darker towards tip; region on base below end of red-brown stripe from eye wholly iridescent, its upper portion blue, lower whitish. Pelvic mainly greenish with some bluish iridescence; a wide median stripe of light yellowish olive; a prominent dark grey-black proconcave arc across whole of distal border; in some examples almost wholly dusky. Anal membrane in one specimen reddish brown basally, then becoming yellowish, finally darkening distally; in another specimen almost wholly yellowish grey, with brief distal darkening; rays of both reddish brown. Caudal rays hyaline, membrane dusky olive; a conspicuous clear yellow arc along most of upper border; crossed by six proconcave arcs; in one example arcs, in succession from base, pink-red, olive, pink-red darker than first, olive similar to second, approaching violet, violet, in another purple, olive, dark purple, olive, extremely dark purple, olive, dark purple.

TABLE 7

Arenigobius tamarensis (Johnston, 1883). Specification of standard length, mm, of a sample of 402 topotypical specimens; also specification of standard length, mm, and, as permillages of standard length (*TLs*),of head, trunk, tail (to hypural), caudal fin of a subsample of 100 individuals. In bottom line 'expected' = frequency in normal distribution.

Statistic	Absolute dimensions, mm		Relative dimensions, *TLs*			
	Standard length	Standard length	Head	Trunk	Tail (to hypural)	Caudal fin
N	402	110	110	110	110	110
Range	15.0-57.0	18.2-57.20	225-398	138-286	424-578	178-318
$\bar{x}$	31.66 ± 0.337	35.43 ± 0.596	297.7 ± 2.68	213.6 ± 2.96	491.14 ± 4.00	248.7 ± 3.90
Md	31.7	36.15	297	206.5	485	250
Mo:*h*=3 mm (*f*)	31 (75)	36 (31)	-	-	-	-
Mo:*h*=10*TLs* units (*f*)	-	-	290 (19)	220 (16)	480 (18)	250 (24)
s	6.70 ± 0.238	6.25 ± 0.421	28.1 ± 1.89	31.0 ± 2.09	42.0 ± 2.83	30.4 ± 2.05
V	21.3 ± 0.8	17.6 ± 1.2	9.4 ± 0.6	14.5 ± 1.0	8.5 ± 0.6	12.2 ± 0.8
Sk	− 0.160	− 0.348	+0.0696	+0.667	+0.455	− 0.131
Within $\bar{x} \pm s$ ('expected')	307 (274)	67 (75)	75 (75)	72 (75)	83 (75)	77 (75)

Arenigobius tamarensis (Johnston, 1883)

Gobius tamarensis Johnston, 1883, *Pap. Proc. R. Soc. Tasm.* (1882), p.120. Type locality: Tamar river, Tasmania ('enters the fresh water of the Tamar').
Gobius tamarensis Whitley, 1929, *Pap. Proc. R. Soc. Tasm.* (1928), p.61 (Johnston MS).
Gobius tasmanicus Whitley, 1929, *Pap. Proc. R. Soc. Tasm.* (1928), p.62 (ex Johnston MS). Type locality: Tamar, Launceston ('brackish water').
Arenigobius tamarensis Scott, 1935, *Pap. Proc. R. Soc. Tasm.* (1934), p.50, pl. 4, fig. 1.
Id. Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89 (1), p.55.

History of species

Johnston's original account of his *Gobius tamarensis* is a somewhat brief one, ending with the statement it 'approaches very close to *Gobius lateralis* (Macleay)': in his redaction of Johnston's memoranda Whitley (1929a) stated that his notes are 'practically the same as the text of the published description,' except for the addition of some measurements (quoted) of an example of total length 2 11/16 inches (68 mm). A full account of the species, based on five examples 67.5-84.5 in total length, and accompanied by a figure was given by the writer forty years ago (1935, p.50, pl. iv, fig.1), this treatment suggesting *Gobius tasmanicus* Whitley, 1929 (based on Johnston MS) is synonymic, a view later accepted by Whitley in his definitive Australian species name-list (1964).

The species appears, as *Gobius tamarensis*, in Johnston (1891), Lord (1923, 1927), Lord & Scott (1924), [who list it separately, but observe it is 'probably identical with' *Gobius lateralis* (Macleay, 1881); date rendered 1880] McCulloch & Ogilby (1919), McCulloch (1929), and, as *Arenigobius tamarensis*, in Whitley (1964) — none of the references does more than list it, and, as far as can be ascertained, no addition to our knowledge of it has followed the appearance of the 1935 description and figure. Some data based on recent extensive collecting are here offered, preceded by a brief consideration of its generic status.

Generic status

Pointing out that McCulloch & Ogilby in their important review of our gobiid fauna realised a necessity for dividing cumbersome larger genera such as *Gobius* Linné, 1758, but themselves took no such action, Whitley (1930) expressed the view that future work on the group would be rendered easier by the provision of some new generic names for Australian species. Accordingly he listed seven such names, noting for each only its genotype, but stating that generic characters can be derived from McCulloch & Ogilby's key. *Arenigobius*, with genotype *Gobius bifrenatus* Kner, 1865, was thus proposed; this genus coming later, in the name-list of 1964, to include also *A. tamarensis* (Johnston, 1883), *A. frenatus* (Günther, 1861), *A. castelnaui* (Macleay, 1881). (It may be noted, in passing, Scott *et al.* (1974) continued to refer Kner's species to *Gobius*.).

A formal diagnosis of *Arenigobius* has thus not been published. As potentially characterized in the key by McCulloch & Ogilby, it would include the following features (cited in order of their appearance there): soft dorsal and anal 'shorter', free from caudal; body scaly; chin and mandible without barbels; first dorsal with 6 spines; head with only microscopic papillae in rows; opercles naked or nearly naked, cheeks naked; exposed edge of shoulder girdle smooth; upper pectoral rays not free nor different from the others; tongue not deeply notched; head 'longer', without spines or large papillae; scales 'larger', 36 or less in a longitudinal row; nape and greater portion of neck naked; gill-openings not extending forward below, fifth ventral ray as long as the fourth; breast and pectoral base scaly; caudal pointed, body 'longer'.

The last feature but one calls for comment. While McCulloch & Ogilby's key

requires that both breast and pectoral base be scaly, their account of (*Gobius*) *bifrenatus* correctly reports thorax scaly, pectoral base naked, features found also in the present species [scales 'cease, on the dorsal surface, at about the level of the hinder edge of the pectoral base mesially, and a little in advance of the posterior border laterally, and, on the lower surface, at about the level of the origin of the ventrals; pectoral base naked' (Scott 1935, p.51)] Thus in respect of the condition of the pectoral base Johnston's species is in agreement with that found in the genotype of *Arenigobius*; though not, as predicated in Whitley's paper, in conformity with the specification of the key.

All other characters of the key as listed above are applicable to our fish, which is accordingly here referred to *Arenigobius*, with the specification of that genus providing for a naked pectoral base.

Material

Collections made by Mr R.H. Green, Queen Victoria Museum and other members of the Museum staff in the Tamar during the course of an ecological survey of some sections of the river in March and April 1975 included long series of gobies (chiefly the present species; 215 examples of *Arenigobius bifrenatus*, the subject of some observations above; 10 specimens of an apparently undescribed species), together with 11 other species of fish (see next section).

Material of the present species taken at West Arm, approximately 10 km from the mouth of the estuary, on 3 March 1975, sample (B_1), and on 5 March 1975, samples (A_1), (B_2),(C_1),(D) (Q.V.M. Reg. No. 1975/5/35) comprises samples from different zones, as follows. Sample (A) above tide level, 819 individuals, *Ls* 21.5-67.5, *Lt* 25.8-83.0: in one jar (of two), with 374 specimens, only 2 exceed 59 mm in *Ls*. Sample (B), comprising B_1 from a single shallow pool on a mudflat (3 March), 402 (this sample is discussed below), (B_2) on tidal mudflats (5 March), 1034, *Ls* 15.1-58.2, *Lt* 19.0-72.9. Sample (C) below high tide, 233, *Ls* 8.3-54.0, *Lt* 10.9-65.1. Sample (D) main stream, 952, *Ls* 17.5-59.5, *Lt* 23.0-74.3

Two further samples were secured at other points on the river: (E), York Town Rivulet, approximately 14 km from the sea, 16 April 1975 (Q.V.M. Reg. No. 1975/5/52), 86, frequency distribution (6 classes, 20-25...45-50) 12, 19, 22, 29, 3, 1:(F), Andersons Creek, approximately 13 km from the sea, 23 April 1975 (Q.V.M. Reg. No. 1975/5/63), 236, frequency distribution (9 classes, 10-15...50-55), 1, 21, 73, 58, 54, 19, 6, 2, 2.

Associated species

Sample (F) includes 10 specimens of an apparently undescribed goby (represented in the Museum's collections by two other examples from the Tamar river, one from a mud pool at West Arm, and one from Muddy Creek, some 42 km from river mouth). Fish other than Gobiidae taken during the survey comprise: *Galaxias maculatus* (Jenyns, 1862, *Galaxias truttaceus* (Cuvier, 1816), *Ammotretis rostratus* Günther, 1842 an apparently new species of *Rhombosolea* Gunther, 1862, *Aldrichetta forsteri* (Cuvier, 1836), *Taeniomembras tamarensis* (Johnston, 1883), *Gymnapistes marmoratus* (Cuvier, 1829), some notes on this species appear below), *Girella tricuspidata* (Quoy & Gaimard, 1824), (juv.), *Arripis georgianus* (Valenciennes, 1831) (juv.) *Arripis trutta esper* Whitley,1951 (juv.), *Sphaeroides hamiltoni* (Richardson, 1843).

Frequency distributions

For sample (B_1) the frequency distributions of the standard lengths, in mm, of the whole sample (402 fish) and of a subsample (110) selected for more detailed investigation below, and, as *TLs*, of the four regional lengths head, trunk, tail, caudal fin in the subsample, as specified in table 7, are as follows.

Standard length, 402 specimens, 15 classes, 14.5-17.4...56.5-59.4: 3, 10, 29, 44,

66, 75, 61, 73, 19, 9, 6, 2, 4, 0, 1; 110 specimens, 14 classes, 17.5-18.4... 56.5-57.4: 4, 6, 7, 9, 10, 14, 31, 10, 6, 6, 2, 4, 0, 1.

Head, 110, 18 classes, 225-234...395-404: 3, 1, 5, 5, 10, 8, 18, 18, 14, 10, 8, 4, 5, 0, 0, 0, 0, 1.

Trunk, 110, 16 classes, 135-144...285-294: 2, 1, 3, 6, 11, 8, 12, 10, 16, 15, 7, 8, 6, 2, 0, 3.

Tail, to hypural, 110, 17 classes, 415-424...575-584: 1, 2, 4, 7, 12, 10, 18, 11, 10, 5, 9, 10, 2, 4, 3, 1, 1.

Caudal fin, 110, 15 classes, 175-184...315-324: 2, 3, 2, 9, 4, 12, 18, 24, 10, 5, 6, 4, 6, 0, 5.

Though the *Ls* distribution of the whole sample shows no indication of bimodality, the coefficient of variation (21.3 ± 0.8) is somewhat unexpectedly high. The reason for this is unclear — it may perhaps be attributed to variation in size in the sexes: other possibilities that suggest themselves include, first, that of the period of growth involved being considerable, and/or general environmental conditions being markedly variable, secondly, that of an extended period of hatching (the latter situation would seem compatible with the fact that the number of individuals of length above the modal length is 15% greater than the number of individuals of length below it; however, mean and median are, to measured degree of precision, identical).

Relative growth

Correlation of standard length with the relative lengths (measured as permillages of standard length) of head, trunk, tail (to hypural), caudal fin in the subsample have been investigated with the following results.

Head. Relative length of head increases with increasing standard length of fish: $r = +0.312$ ($z = 0.322$), $t = 4.266$ ***.

Trunk. The investigated subsample presents no significant evidence of change during growth in relative length of trunk: $r = \pm 0.0471$ ($z = 0.0472$), $t = 0.0490$.

Tail, measured to hypural joint. Tail without caudal fin shows a marked decrease in relative length with growth: $r = -0.442$ ($z = 0.475$), $t = 5.091$ ***.

Caudal fin. The fin itself also shows a negative correlation: $r = -0.288$ ($z = 0.297$), $t = 3.131$**.

The pattern of relative growth in the present species of the regions selected for examination is, somewhat surprisingly, markedly different from that found in the sample of *Arenigobius bifrenatus* considered above, the sequence of correlations for the four regions, proceeding caudad, being in the latter species negative, positive, (as measured by difference of means of subsamples), no significant correlation, positive, while in the present form the sequence is positive, no significant correlation, negative, negative. The positive correlation of the caudal fin in *A. bifrenatus* is clearly connected with the increased growth in that species of the median rays that leads to the development in older fish of the characteristic posterior attenuation of the fin, whereas the caudal in *A. tamarensis* is more or less broadly rounded, with no or little median extension. It would be of interest to determine whether or no a negative correlation is regularly found in species with the (among Australian forms more usual) rounded or rounded truncate fin.

Reference to tables 6 and 7 shows the combined length of head and trunk (and hence length of tail without caudal fin) is significantly the same in the present two species.

Character of regional regressions

Different correlations with standard length of the several body regions examined thus being established, the need that next arises is that of ascertaining whether the relationships are of the first or of a higher degree, and of determining their parameters. The measurements of 110 individuals arranged in ascending order of magnitude of standard length have been divided into five sets, and in each of these the standard length (mm) and the lengths (*TLs*) of head, trunk, tail to hypural, caudal fin have been summed. The plotting of these results shows the relationship is in each case clearly a linear one. The regression equations are set out below.

Head (*H*) on standard length (*L*): $H = 0.2716L + 27.09$; $t = 15.805$***. The summed values for the five series (predicted, in parentheses) are 136.6 (140.1), 219.8 (216.7), 244.9 (241.9), 251.5 (255.6), 303.7 (306.4).

Trunk (*B*; from *b*ody): $B = 0.2005L + 167.28$; $t = 7.337$**: 110.1 (99.3), 139.4 (155.9), 165.3 (174.9), 190.9 (184.6), 230.7 (222.3).

Tail, to hypural (*T*): $T = 0.3382L + 118.52$; $t = 17.197$***: 266.5 (259.3), 344.4 (354.7), 383.9 (386.1), 400.4 (403.1), 474.3 (466.3).

Caudal fin (*F*): $F = 0.1769L + 56.91$; $t = 13.416$***: 132.6 (130.5), 179.2 (180.4), 201.6 (196.2), 195.0 (205.8), 243.9 (238.8).

It is to be noted the magnitudes plotted are summed values for the set, not its arithmetic mean; to obtain equations for $\bar{H}$, $\bar{B}$, $\bar{T}$, $\bar{F}$ the independent term needs in each case to be divided by 22, the coefficients of the variates (slopes) remaining unchanged: further, t values are hence those resulting from the use as primary data of the five sums, with d.f. = 3.

Remarks

The 1935 account of this species, based on two lighter coloured individuals, *Lt* 75, 67.5 (latter figured) and three darker coloured, *Lt* 72.5, 77, 84.5, taken in the Tamar in March and April 1934, the first series from the Launceston wharf, the second from the upper reaches of the river near Tamar Island, about 45 km from the sea, provides a reasonably adequate description of it: examination of the present extensive additional material provides occasion for the subjoined remarks.

Johnston noted 4 branchiostegals in *A. tamarensis* and 5 in *G. tasmanicus* (the latter treated in the 1935 paper as a synonym of the former). The 1935 count of 5 for *A. tamarensis* holds good in the present material. However, one ray, the lowest, is much shorter than the rest and is set far apart from them, the distance between its base and base of ray nearest it being subequal to the interval within which the insertions of all the four other rays are comprised: this smallest, lowest ray could readily be overlooked.

Light coloured and dark coloured individuals — the extremes of the two types markedly different in general aspect — are found in various gradations in all samples examined, and in individuals of all sizes save the smallest. However, the basic elements of the colour pattern on the body — a midlateral row of dark spots, modally 7, more or less equidistant, from behind pectoral to caudal base, and 4 dark areas at dorsal profile (1935, pl. 4, fig. 1) — are almost invariably conspicuous, or are at least adnumbrated. In the lighter examples (as in that figured) few or no other markings are present: in darker examples almost the whole of the lateral surface, from dorsal profile to within a short distance of ventral, may bear numerous small spots, splashes, or short bars of chromatophores, these areas of pigmentation being much smaller and decidedly less intense than those constituting the main elements of the pattern. On the head the basic markings are less constant than those on the body, the dark spot on the operculum and the less extensive spot on the preoperculum usually

being present, but being variable in size and in depth of colour, and being sometimes absent, the preopercular spot the more frequently so. Both pectoral and ventral range from being virtually colourless through an intermediate stage in which each of the rays is defined by a single series of minute closely-set melanophores to, in a few individuals, an overall state of pronounced duskiness.

In Johnston's description the pectoral was noted as 'reaching to vertical from third ray of second dorsal', while in the 1935 material it was not found to extend beyond the origin of the fin. In the present samples it modally falls at, or just short of, level of dorsal origin; however, in occasional examples it extends as far as below the second or third ray. The ventrals may just fail to reach, or may extend shortly beyond, the vent, the former condition appearing to be more common in smaller fish.

With a total length of 84.5 mm, the largest of the five 1935 specimens would appear to be close to the maximum size of the species, the largest individual here examined having a total length of 83.0, the next largest (2) 78.9, and only half a dozen or so exceeding 70. Johnston reported 'two to two and three-fourths inches [51-70 mm] long', while his memoranda, redacted by Whitley (1929a, p.62), noted an example of total length 2 11/16 inches [68 mm]. The smallest specimen in our material is 8.3 in standard, 10.9 in total, length.

Family SCORPAENIDAE

Genus *GYMNAPISTES* Swainson, 1839

Gymnapistes Swainson, 1839, *Nat. Hist. Classif. Fish. Amphib. Rept.*, 2, pp.63, 180, 265. Logotype, *Apistus marmoratus* Cuvier.

Gymnapistes marmoratus (Cuvier, 1829)

Apistus marmoratus Cuvier, 1829, *Hist. Nat. Poiss.*, 4, p.416. Type locality: 'Timor' (Péron). [Check-list, 'probably = West Australia'].
Apistes marmoratus Gray, 1838, *Ann. Mag. Nat. Hist.* 1, p.111. Type locality: Van Dieman's Land (Gunn).

Remarks

Some observations on the more taxonomically important features and their variation, life colours, behaviour, based on two examples, *Ls* 105.5, 120, from George Bay, east coast, together with notes on the local history and the vernacular names of the species appeared in Part IX (1960). The present contribution provides some morphometric data on, and on account of the colour pattern in, a juvenile sample; together with data on relative regional growth derived from a comparison of this sample with an adult sample. Length measurements of the juveniles are found not to be in conformity with a published version of the growth curve of the species.

Material

(*A*) Juveniles. A series of 36 specimens, *Ls* 16.6-25.1, *Lt* 22.0-33.5, taken during an ecological survey by the Queen Victoria Museum of part of the Tamar river, at West Arm, (approximately 10 km from the sea) on 5 March 1975 (Q.V.M. Reg. No. 1975/5/36).

(*B*) Adults. (*a*) *Ls* 114, *Lt* 140, Kelso, Tamar river, in tidal grass, 5 February, R.H. Green, Q.V.M. Reg. No. 1975/5/60; (*b*) *Ls* 115, *Lt* 143, same history; (*c*) *Ls* 119, *Lt* 147, Greens Beach, north coast, 5-7 November 1966, R.H. Green, Reg. No. 1972/5/466; (*d*) *Ls* 126, *Lt* 158, Swan River, east coast, 9 October 1971, A. Brooks, Reg. No. 1972/5/330; (*e*) *Ls* 130.5, *Lt* 165, 11 November, 1970, George Bay, east coast, W.J. Head, Reg. No. 1970/5/30; (*f*) *Ls* 132, *Lt* 158, Beauty Point, Tamar river, 22 July 1964, P. Rowley, Reg. No. 1964/5/2; (*g*) *Ls* 138.5, *Lt* 166.5, Swan Point, Tamar river, 16 March

1967, Reg. No. 1967/5/10; (*h*) *Ls* 153, *Lt* 192.5, Clifton Beach, southern Tasmania, 2 November 1964, M.Mooney, Reg. No. 1969/5/31.

Length specifications

Standard and total lengths of each of the 8 adult individuals have been noted above: the range, mean, standard deviation of *Ls* being 114-153, 128.50 ± 4.34, 12.28 ± 3.07; of *Lt* 140-192.5, 158.75 ± 6.43; 18.18 ± 4.54. In the sample of 36 juveniles the standard length range is 16.6-25.1, mean 20.74 ± 0.372, median 20.6, standard deviation 2.23 ± 0.263, coefficient of variation 10.8 ± 1.3, frequency distribution (9 classes, 16.5-17.4...24.5-25.4) 3, 2, 6, 6, 5, 3, 7, 3, 1, with 23 (*cf.*, normal curve, 25) entries within $\bar{x} \pm s$. For total length the corresponding values are 22.0-33.5, 27.56 ± 0.510, 27.4, 3.06 ± 0.361, 11.1 ± 1.3, (13 classes, 21.5-22.4...33.5-34.4) 3, 1, 1, 5, 3, 5, 3, 4, 3, 6, 1, 0, 1 (25).

Head

With length of head expressed as permillage of standard length, the range, mean, standard deviation, coefficient of variation in the adult fish are 371-425, 386.6 ± 5.44, 15.4 ± 3.85, 4.0 ± 1.0. For the juveniles the values are 382-475, 420.6 ± 3.46, 20.8 ± 2.45, 4.9 ± 0.6.

It will be seen the mean relative length of head in the young fish considerably (by 8.8%) exceeds that in the adult. A test of the significance of the difference of the means shows it to be highly significant (t = 4.255***).

Preanal length

In the adult fish the *TLs* range, mean, standard deviation, coefficient of variation of the combined length of head and body (*TLs*) are 615-701, 652.0 ± 9.94, 28.1 ± 7.03, 4.3 ± 1.1: in the juveniles 650-704, 623 ± 4.29, 33.2 ± 3.91, 5.3 ± 0.6. For difference of means t = 2.121*.

Thus although in juveniles the mean relative length of head is greater than in adults, the juvenile length to vent is the lesser. By simple subtraction of the means, *TLs* length of trunk in adult is 265.9, in juvenile 203.3, *i.e.*, with growth, relative lengths of head and of tail (vent-hypural) decrease, while relative length of trunk increases.

Caudal fin

Statistics in sequence as before for relative length of caudal fin (*Lt* − *Ls*) are, adults, 197-264, 235.1 ± 8.27, 23.4 ± 5.85, 9.9 ± 2.5; juveniles, 264-450, 333.4 ± 6.97, 41.9 ± 4.93, 12.6 ± 1.5.

The great excess of the mean relative length of the fin in the young fish (42%; ranges barely overlapping) is clearly highly significant; t = 6.277***.

Depth

Statistics for greatest depth (*TLs*) are, adults, 314-409, 359.1 ± 11.3, 32.2 ± 8.05, 9.0 ± 2.3; juveniles, 312-441, 374.1 ± 4.74, 28.4 ± 3.35, 7.6 ± 0.9. The difference of the means is not statistically significant (t = 1.283).

Growth curve

A growth curve for *Gymnapistes marmoratus* in Tasmania has been proposed by Grant (1972), total, not standard, length being considered throughout; all dimensions in cm. Measurements were made of 103 males and 67 females, and, no great difference in size between the sexes being found (on the published data, a test of the difference of the means yields a non-significant t value of 1.385), the data for the sexes were pooled for the purposes of computation (sexes plotted separately, however, in fig. 7; not in figs 5, 6), the range of the weighted means over the observed growth period being 8.0-17.7 (table 1). Age was determined by otolith examination, and was regarded as

ranging in the material examined from 2 to 13 years.

The formulation employed was the growth equation of von Bertalanffy (1937, 1938) namely, $L_t = L_\infty \ [\ 1 - \exp\{-K\ (t - t_o)\}\ ]$, in which Lt = length of fish at age t years, L_∞ = maximum length towards which fish is tending, K = rate of change of length movement, t_o = hypothetical time at which the fish would have been zero length had it always grown in accordance with the expression. Parameters were obtained as follows. The value of L_∞ was arrived at by means of the Walford transformation of the growth curve (Walford 1946), and was found (fig. 5) to be 21.4. The parameters K and t_o were obtained by a plot (fig. 6) of $\log_e$ ($\log L - \log L_t$) against t years (Ricker 1958), the slope of the regression being $-K = 0.1168$ and t_o coming out at -2.3 years. Substitution of these values in the von Bertalanffy equation gives the growth curve of *Gymnaspistes marmoratus* as $L_t = 21.4\ [\ 1 - \exp\{-\ 0.1168\ (t + 2.3)\}\ ]$. A comparison of calculated with observed lengths is presented in Grant's fig. 7, which shows the calculated curve based on data for sexes pooled, but plots also male and female values separately.

The earliest age for which measurements are available is 2 years: however, the fitted curve is extrapolated back to 0 years and beyond to t_o. The length at 0 years is shown in the graph as 5.0 cm (by calculation from the equation 5.04). It is of interest to note that in the Tamar River sample here reported upon total length (2.20-3.35, $\bar{x}$ 2.76 cm) falls well below the predicted length at zero age, the largest, mean and smallest lengths being only 66%, 55%, 44% of that estimate, and 8 of 36 individuals failing to reach half the calculated size.

Thus, while providing a satisfactory fit for ages 4-13 years (less satisfactory for ages 2-4), the published curve is probably not applicable below age 2, certainly not for age 0. Some consideration is given below to two lines of inquiry.

In the first of these the weighted mean lengths have been plotted against their year classes 2-13: the length data have been calculated directly from table 2 (mean length shown in table 1 records means only to 0.1 cm; if data in table 2 are correct, several numerical errors occur in table 1). It is found a clearer picture of the general nature of the size change with age is presented by this single graph than any readily to be gathered from inspection of the male and female graphs shown together in fig. 7 (along with calculated curve). As thus plotted, the curve for ages 4-13 can be eye-fitted by a single sweep of (upwardly convex) curve. However, between year 2 and year 4 there appears to occur a recognizable point of inflexion, the overall sense of the graph obtained by joining 2 to 3 and 3 to 4 by linear segments being upwardly concave, and no continuation to the left of the curve between ages 13 and 4 to pass, without marked change of gradient, through points for years 3 and 2 being feasible. The excesses of estimated over plotted magnitudes at the region of oversweep of the curve are considerable, those at years 2, 3, 4 being 5.4%, 2.6%, 4.1%, respectively, compared with 0.1%-1.5%, $\bar{x}$ = 0.68% found among the remaining 9 year classes. This excess of calculated over measured values in the early years involves compensatory deficits in the later years; hence, instead of positive and negative deviations being distributed at random along the curve, the customary outcome of the intrinsic variability of samples (in the equation noted below, confined to the years 4-13, the sequence of sign of the deviations is +, −, +, +, −, +, −, −, +), there arises a systematic fitting bias, expressed as a raising of the graph above plotted points in early years with concomitant lowering of the graph below points in later years.

In a second line of approach a simple exponential relation of the form $Lt = bt^k$, which, expressed as $\log L_t = k \log t + \log b$, yields a convenient linear graph, has been looked at. The plot is found to be separable at sight into two elements, a significantly linear segment covering ages 4-13, and a line of greater slope, joining the coordinates for years 2 and 3 — a qualitative discontinuity in the growth curve round about age 4, or earlier, is thus again encountered. A convenient indication of the

magnitude of the change of direction is provided by a comparison of the slopes of the two segments, namely, 0.4505, 0.3599; that for the points 3 and 4 being 0.6607, that for 2 and 4 (3 omitted) 0.5378. The equation for the 4-13 years segment is log L_t = 0.3599 log t + 0.8512; (Student's) t = 52.927** . Over the relevant age range this equation provides a somewhat better fit than the published equation, percentage deviations of predicted from observed lengths being 0.2-1.5, $\bar{x}$ = 0.7, as against 0.1-4.1, $\bar{x}$ = 1.3. As might be expected, neither the linear graph for years 4-13 nor that for years 2-3 yields on extrapolation a biologically valid magnitude for L_o, the values being 7.05, 5.87 cm.

In summary: total lengths (2.20-3.35, $\bar{x}$ = 2.76 cm) found in a sample of *Gymnapistes marmoratus* from the Tamar River fall well below the calculated length at zero age, 5.04 cm, in a published growth curve for the species (Grant, 1972); the published curve, while providing a satisfactory fit for age classes 4-13 (fit for years 2-4 less satisfactory), is not applicable to fish in the age range 0-2 years; in early years the curve needs to exhibit a steeper gradient, and it is possible the total curve may take a sigmoid form.

In a study of reproduction, growth and size allometry of *Mugil cephalus* Linné, 1758 from North Queensland inshore waters (Grant and Spain 1975) that came to notice a few days after the above was written the authors, while calculating the von Bertalanffy equation for this species (comparative observed and calculated growth curves shown in fig. 10), express some reservations about the procedure, reporting 'The von Bertalanffy equation closely approximates observed growth in larger fish, but is a poor fit at the lower limits of growth.' (p. 196). Noting the life history includes lag phases in the larval stage and at puberty, the growth curve thus being sigmoid, they remark 'Modelling the growth of *M. cephalus* by use of a relatively simple growth function thus seems somewhat ambitious (von Bertalmanffy 1964). It may better be approached by attempting to model the several apparent growth phases independently'. The relevance of these extracts to the present discussion is apparent — they cannot, of course, be taken, however, as representing fully the authors' views, for which reference should be made to the paper cited.

Adult coloration

Concerning the coloration of adults Macleay (1881) wrote 'dirty yellowish, largely marbled with brown'; McCulloch (1915), who figured a Western Australian example 137 mm long, stated 'The markings .... differ very much in several specimens from various localities, both in form and intensity, though their disposition is much the same in all; in some the larger dark blotches are brown, and surrounded by more or less abundant mottlings, while in others they are deep black on a plain white background'; Waite (1906) remarked of Victorian specimens 'the markings appear to be very constant and remarkably well defined', and later (1923) gave as a short diagnosis 'greyish yellow marbled with brown'. These accounts all refer to preserved material: as reported in Part IX (1960) live fish from George Bay, east coast, exhibited a very wide range of colours and tints, including pale and medium grey, greenish grey, green, greenish gold, flesh, flesh tinted with gold, white, warm and reddish and golden brown, dusky, olivaceous, pink, pinkish fawn, pale orange, purple.

Juvenile colour pattern

All descriptions agree, and examination of specimens confirms, that the major markings in the adult are blotches (one or more of which may be quite large) and a number of rather widely variable mottlings. The sample of juvenile specimens here reported upon exhibits a noticeably different, decidedly bolder series of markings, the basic elements of which are so distinctive and so regularly developed as strongly to suggest it represents a characteristic juvenile colour pattern.

The most striking feature of this pattern is the presence on the side of at least two conspicuous dark brown or blackish bars; first bar, modally about an eye diameter

in width, completely covering caudal peduncle and adjoining region forward beyond level of insertion of membrane of dorsal to, or almost to, membrane of anal; anterior border proconcave, usually deeply so; posterior border overall strongly proconvex, somewhat furcate, constituted mainly by two large lateral continuations back on to base of caudal, each more or less in the form of rather more than half a cone, extending outward right to edge of fin, its most caudad point just internad of external ray: second bar a little narrower than first, in advance of it by rather more than its median anteroposterior extension, running subvertically, continuous from profile to profile, its slightly proconvex borders generally parallel throughout most of their length, but usually showing some divergence at their upper end, below middle of base of soft dorsal, anterior border here frequently giving rise an often subtriangular forward spur, subequal in length to vertical height of whole bar. In some individuals a rather conspicuous dark marking runs down as a continuous bar from near middle of base of spinous dorsal almost to ventral profile; more commonly this marking is interrupted, being represented usually by two, occasionally by three, segments, modally about as wide as high. Of these three bars, none normally occurs in the adult, though remants of that at base of caudal may be traceable in an occasional individual. In most specimens a dark brown or black subrectangular or ovoid patch occupies most of area between upper border of operculum and fin base above it. Ventral surface whitish and/or (especially on chest) yellowish; marked, regularly in front and frequently behind, by scattered red-brown or dark brown chromatophores.

Dark brown markings on head tolerably extensive, less regularly patterned than those on body; comprising, when best developed, a conspicuous downwardly and backwardly oblique bar from orbit (regularly developed, but quite variable in both extent and intensity), its width subequal to diameter of pupil, variable patches behind eye, above eye, on dorsum of snout, on opercle. Ventral surface sprinkled, sparsely or abundantly , with deep brown or reddish brown chromatophores. Lips usually mottled.

Spinous dorsal with dark blotches, commonly black or approaching black, characteristically one covering first two-three spines, then suffering an interruption for one or two spines, or continuing unbroken to near sixth or seventh spine; usually a small dark marking on last spine or two. Soft dorsal with a large dark area, modally occupying its middle one-third, or rather more. Anal dark brown or intensely black on anterior portion, continuous here with penultimate bar on flank; rest of fin either greyish or conspicuously white. Pectoral mostly black or blackish, lower one or two rays white; sometimes base of fin, or middle of its length, whitish. Ventral usually black proximally, white or whitish distally; occasionally white proximally, black distally. Caudal characteristically exhibiting four regions: basal one-eight the dark half cones continued from peduncle; thereafter to about middle of length silvery; posterior half dark brown or blackish nearly to tip, which is white or greyish.

Family APLOACTINIDAE

The above form of the family name is that adopted by Greenwood *et al.* in their provisional classification of living teleosts (1966) to include Aplodactylidae and, as a queried entry, Bathyaploactidae. The form Aploactidae was adopted in the general classifications of Jordan (1923) and Berg (1940); this is the version of the Checklist (McCulloch, 1929) and that adopted by most Australian writers, *e.g.*, (Lucas 1890), Waite (1921), Whitley (1933), Scott (1942), (T.D.) Scott (1962), Munro (1957), Scott *et al.* (1974). Earlier these fish were usually grouped (Günther 1880, Macleay 1881) with the Scorpaenidae, with the scaleless members of which, sometimes given separate recognition as the Tetrarogidae, they agree in having the anterior dorsal spines constituting a more or less distinct, usually crestlike, section and in showing a reduction in the number of ventral fin rays; differing from them most noticeably in the presence of numerous velvety villi on the skin. Marshall (1964) treated the group as the Aploactinae, a subfamily of the Scorpaenidae. Whitley (1933 , p.98) noted the Synancejidae are not distantly related.

Only two members of the family appear in the Check-list, *Aploactis milesii* Richardson, 1850 (synonym, *Aploactisoma schomburgki* Castelnau) and *Paraploactis trachyderma* Bleeker, 1855 (synonym *Aploactis lichen* De Vis, 1884). Whitley's name-list (1964) added *Adventor elongatus* (Whitley, 1952), *Bathyaploactis curtisensis* Whitley 1933 (with two subspecies), and recognised a subspecies from New South Wales and Victoria of Richardson's species, *Aploactisoma milessi horrenda* Whitley, 1933.

Genus *APLOACTISOMA* Castelnau

Aploactisoma Castelnau, 1972, *Proc. Zool. Acclim. Soc. Vict.* 1, p.244 *et ibid.*, 1873, 2 p.63. Haplotype, *Aploactisoma schomburgki* (= *Aploactis milesii* Richardson, 1850).

Aploactisoma milesii (Richardson, 1850)

Aploactis milesii Richardson 1850, *Proc. Zool. Soc.* London, p.60, *Pisces*, pl.1, figs 1-2. Type locality: King George's Sound, Western Australia.
Aploactis schomburki Castelnau, 1872, *Proc. Zool. Acclim, Soc. Vict.*, 1, p.244. Type locality: St. Vincent's Gulf, South Australia.
Aploactis schomburgkii Castelnau, 1873, *Proc. Zool. Acclim. Soc. Vict.*, 2, p.64.

Occurrence in Tasmania

Though Scott (1962), who followed Whitley in recognizing two subspecies, *A. m. milesii* from Western Australia, South Australia and Tasmania, and *A. m. horrenda* from Victoria and New South Wales, said of the former that it is 'reasonably common' in South Australia, the species would appear not to be abundant in this State, not being included in any of the published local lists — Johnston (1883, 1891), Lord (1923, 1927), Lord & Scott (1924) — or accredited to Tasmania in the Check-list (McCulloch 1929). The first Tasmanian record appeared in Part V of these Observations (1942, p.52), based on a specimen, *Ls* 130, *Lt* 160 (Q.V.M. Reg. No. 1939, 147), taken at Low Head in 5 fathoms (9 m); a specimen, *Ls* 74.8, *Lt* 92.0, collected early in 1975 in Anderson's Bay, Bridport, by Mr Peter Last (Q.V.M. Reg. No. 1975/5/217) is the only other example to come under the writer's notice. Some observations on these two fish follow: data for the smaller specimen are given first throughout.

Fin counts

D. XIII,15; XIV,16, A.13; I,14 = 15?. P.11; 11. V. I, 2; I,2. C.13,13.

Proportions

No set of proportional measurements for this species appears to be available: some dimensions, as permillages of *Ls*, of our examples are noted. Total length 1230, 1236. Length to origin; termination (last spine) of first dorsal 79, 71; 627, 559: of second dorsal 652, 591 (first ray); 976, 945 (last ray) or 996, 969 (membrane) : of anal 623, 587; 909, 945. Length to vent (middle) 556, 563. Length to pectoral origin 279, 236; length of fin 328, 331; longest (4th, 4th) pectoral ray 311, 272. Length to ventral 242, 232; length of fin 178, 153; length of longer (inner, inner) ray 151, 137.

Head 316, 283. Snout 80, 75. Eye 78, 67. Interorbital 80, 92. Length of maxilla 112, 118, greatest width 40, 43, least distance from eye 66, 57. Depth at front of eyes 178, 173, back of eyes 201, 200, opercular border 281, 299, vent 269, 315, immediately behind vent 267, 260, anal termination 120, 142; greatest depth 287, 378; depth of caudal peduncle 107, 106.

Body form

In the terminology of Gregory (1928) the body form is mesosomatic, hypsisomatic, gasterion supapical, gasterion postapical; vertex anterior; gasterion anterior,

gasterion median; mesonotic; mesogastric, bathygastric; leptopygidial; opisthion preuranic. It will be seen that, of the eight variable factors, the first, second, fourth and sixth are represented by two specifications. In each case the first specification, that for the 1975 fish, may be regarded as being normal and definitive; the presence in the 1942 fish of ripe ovaries with numerous eggs produces a marked distention of the abdomen leading to what may be regarded as being an adventiously high value for the anterior ventral vertical and an adventiously posterior location of the gasterion.

General features

A very good and comprehensive description of his *Aploactis milesii* (based on a dried specimen, its condition probably bringing into special prominence the remarkable modelling of the head) was given by Richardson (1850): Castelnau's much shorter account of his *Aploactisoma schomburgki* (1873; as *A. schomburgkii*) was concerned almost entirely with the shapes and dimensions of the fins; while his original notice of the species consists only of the dorsal fin formula and a sentence on coloration. Little is added in later treatments by McCulloch (1915) and Whitley (1933), the chief new contributions being the presentation by the former of some variants in dorsal and anal counts (together with the correction of Castelnau's erroneous statements that there are teeth on the palatines and 'two teeth rather larger than the others' at the front of a longitudinal ridge at the symphysis of the upper jaw), and the calling of attention by the latter author to differences in shape of villi, size, relative depth, features used to distinguish subspecies (see Discussion, below). Some comparative observations on our material follow.

In specimen (*b*) both the dorsal count, XIV,16, and the anal count XV (I,14), are higher than in Richardson's type, XIV, 14, and 12; than in Castelnau's two specimens, XII,15, and I,11; and than in any of the eight examples examined by McCulloch, with ranges 28-29 (XIII, XIV, 14-15) and 12-13 (I,11-12). Height 'nearly one-fourth of length of fish, caudal included' (Richardson), 'four times in the total length' (Castelnau), here 4.28, 3.27 in *Lt*, or 3.48, 2.71 in *Ls*, the markedly greater relative depth of the larger specimen being accounted for, as noted above, by distension of the abdomen by the presence of seasonally enlarged ovaries, depth immediately behind vent (3.74, 3.85 in *Ls*) showing no significant difference. Head in total length: Richardson's data would give about four times; Castelnau, three and two-thirds; here 3.90, 4.44. Eye in head: Castelnau, five times; here 4.07, 4.23.

In Richardson's statement that the height of the tallest spine is but a little less than that of the head it would appear from his figure that maximum height of head is meant (height of fin subequal to height of body below it): in our specimens it is 1.00, 0.79 height of head below spine, but is 1.50, 2.00 times in greatest head depth. Castelnau noted the length of the longest dorsal spine as equal to distance from tip of snout to middle of orbit; in both Tasmanian fish it somewhat exceeds distance from tip of snout to posterior border of orbit. Both Richardson and Castelnau specify the second spine as the longest, and this is the case in (*b*); however in (*a*) the first spine is slightly longer than the second, though the latter stands tallest, the extra length of the first being related to its more inferior insertion. The dorsal presents a dip in outline in Richardson's fish, in Castelnau's and in our (*b*), the fin in each case rising from first to second spine, then decreasing to fifth-sixth, fifth, eighth, respectively, thereafter increasing in length to last; the shortest being in our specimen 0.46 of the largest, 0.76 of the last. However, in the smaller individual the spines decrease in length from first to last, the latter being 0.29 of the former. For further consideration of dorsal spines, see Fin patterns below.

Additional descriptive data

Some features not, or inadequately, noticed in published accounts may be here considered. Maxillary extends to below 0.5, 0.3 eye (in illustration stops well short of eye). The lateral line runs backwards and somewhat downward from just behind opercular angle to midline of flank at level of vent, thereafter proceeding almost

horizontally, to end at caudal base a trifle nearer to upper than to lower margin of peduncle. In (*b*), in which it is more readily observable, it comprises 12 elements, the first eight of which take the form of a slender tapering process, thickly beset with minute copies of itself, most numerous proximally, sometimes completely absent distally, the whole structure surrounded at its base by a cluster of dermal processes, separate from, and noticably smaller than, those on the body nearby; between adjacent tentacles a narrow strip lacking the ordinary processes but sometimes bearing a short median strip of about half a dozen much smaller processes; largest tentacle subequal to eye, size decreasing caudad. The posterior 4 elements each consist of an anteroposteriorly set strip of small processes, much as if the free tentacle of the anterior part of the series had been depressed and become adnate: in the well developed example at base of caudal, about half an eye diameter in length, there are 16 processes, very closely set, arranged biserially.

The anterior nostril, just below level of eye, a little closer to orbit than to upper lip, presents a backwardly, and in (*b*) somewhat downwardly, directed membranous flap, subrectangular in (*b*) subtriangular in (*a*), upper border convex, lower sigmoid. The posterior nostril appears to be represented by a fleshy envelope, somewhat similar to the anterior nostril, lying in the front of a well developed adorbital depression flanking on either side the conspicuous medial depression on the forehead: neighbouring minute circular naris-like aperture in the summit of a low mammilliform eminence lying close against the transverse ridge of the prefrontal that constitutes the posterior wall of this lateral depression and that is confluent internally with the trenchant circumorbital ridge at 10 o'clock (left side viewed), being probably a simple open cephalic pore, several of which occur (as noticed by Richardson) on the mandible. The characteristic subtriangular median frontal depression (in this genus base facing mouth; in *Paraploactis* and *Adventor* facing dorsal fin) is wholly filled in the larger specimen with a distended smooth whitish translucent bag: the presence of this structure may possibly be due to the fish having been subjected to some abrupt change in pressure, an inflated tyre of similar material surrounding each eye.

The anterior gill arch, which is more evenly bowed, less sharply divisible into upper and lower limbs than usual, bears in its lower half three mounded, minutely spinulose gill rakers, in general more or less contiguous, with the first (uppermost) showing most tendency towards being separate; there being also an indication of the continuation of the last as a long ridge; from one to three extremely small rectangular elevations, their height less than one-fifth that of the other elevations, occur separate from, and some distance above, the others, but still within the presumed extent of the lower limb. All teeth villiform, minute: in upper jaw on either side in a boldly curved flat band, broadest anteriorly, decreasing evenly to a point posteriorly, the two bands imperfectly separated at the symphysis by a fleshy strip, part or all of which is mounded; no special enlarged teeth: in lower jaw two similar, but slightly narrower, bands, separated at the symphysis by a narrow groove, naked in the smaller specimen, occupied in the other example by a fleshy process running forward from a crescentic skin-fold that flanks the dentigerous region throughout its length: on vomer in a small lunule. A frenum on the palate contiguous anteriorly with the tooth-band, and nearly as wide as it, is delicately corrugated throughout, with the tip of each ridge produced posteriorly as a short pointed process, the free border of the membrane thus forming a finely denticulate arc. It is conceivable the points on this arc may have been interpreted as a series of palatine teeth.

The dermal papillae cover the greater part of head and body; largest on flanks, smallest on abdomen; absent from part of upper lip, supralabial sulcus, most of lower lip, parts of some cephalic depressions, central portion of anal area, much of branchiostegal membrane, most of lower border of preoperculum. On dorsal and anal they invest virtually whole fin, becoming progressively smaller distally, finally degenerating to minute knobs, which in (*a*) are sparse on the membrane: in (*b*) they extend to the broad tips of the pectoral rays, while in (*a*) they are absent from the tips, here

more slender, more pointed and free for a greater distance, relatively and absolutely, from the membrane. By writers other than Richardson these structures are customarily referred to as villi, usually with the epithet velvety. Richardson, dealing with a dried specimen, speaks of them as 'straight acute spines, each enveloped in a skinny sheath'. When the fingertip is drawn along the body in our material, first in one then in the other direction, the resultant sensation with the large fish is in both cases velvety; with the smaller fish the caudad motion gives a tolerably smooth feel, the cephalad motion a distinctly prickly one. The spine, described by Richardson as straight, in our material somewhat recurved, is either partly bare or is invested in a quite thin membrane in the smaller fish, but is embedded in thick integument in the larger. Papillae in different regions of the head range in form from stout pyriform to slender digitiform, varying in bulk by a factor of 10 or more. The crest of the dorsal in (*b*) bears on each side a dozen specialized papillae of differing size, the largest several times the size of the smallest and five to six times as large as those of the tolerably uniform series of the flank; these are ramose, developing up to a dozen processes.

Some of the complex cephalic armature has been described by Richardson; one remarkable feature, the larger, more posterior of two ridges given off from the first suborbital merits more detailed attention. This ridge, arising from a mounded elevation just below 7 o'clock on the orbit (left side viewed) preceeds downward and forward, increasing in height, for about two-thirds of an eye diameter, and then divaricates, the ridge thus formed, the general sense of which is horizontal, comprising a median upwardly convex arc, flanked on either side by a downwardly convex arc, the elevation as it proceeds becoming thickened and rounded, and being briefly continued in a re-entrant curve directed towards the primary ridge, the two free lateral tips thus assuming a somewhat knobbed appearance. The whole structure exhibits a considerable degree of mobility, the strongly scalloped terminal portion, the fore-and-aft extension of which is about twice the length of the median ridge, being readily raised above the general surface of the cheek, disclosing an area of smooth glistening white integument. This process would appear to be represented also in *Paraploactis*, which genus Bleeker (1865) stated 'Se distingue...par l'armature de son sousorbitair antérieur mobile à la façon des *Apistes*'.

As noted above, the marked distention of the larger individual is due to the presence of ripe gonads. Each ovary is a large broadly fusiform body, approximately 24 mm long, 8 wide, 12 deep; its thin transparent external membrane tightly packed with pale orange ova, nearly all well developed, spherical, 0.7-1.0 mm in diameter; left ovary, viewed from below, with anterior one-third covered by larger lobe of liver, right covered only by tip of smaller lobe.

Our two specimens differ markedly in general appearance, largely as the result of, first, the variation in depth, already noted; secondly, the nature of the general integument, thick and rubber-like in appearance in (*b*), more membranous in (*a*); thirdly the coloration; fourthly, the length-pattern of the dorsal spines: the last two features receive consideration below.

Coloration

Specimen (*a*). Body chiefly almost uniform light tan, a little lighter on lower half of trunk, becoming still lighter ventrally, approaching whitish mesially for about two-thirds of a head length in advance of vent, which is white: flank with fewer than a score of dark markings, three or four of these, first above opercular angle, rest shortly behind this, largest, darkest, approaching black, the remainder scattered, less defined. Head largely concolorous with body, lighter on side in advance of eyes, on chin, and on much of branchiostegal membrane; two or three dark spots behind eye; a subrectangular area darker than rest of cheek just behind gape. Dorsal chiefly concolorous with body; membrane of part of fin above head and that between last three rays somewhat lighter, most so distally; some darker, reddish brown clouding

involving part of upper half of fin from first to third spines; a dark, almost black spot covering distal one-third of membrane between twelfth and fourteenth rays; tips of spines and rays tending to be lighter than remainder. Anal lighter than dorsal, somewhat yellowish fawn; conspicuous broad dark bar, shading internally to reddish, on distal one-fourth of rays 11-13 and their membrane, continued forward, decreasing in height, on tips of three preceding rays, and, less deep in colour, on tips of rays 14,15. Pectoral mostly concolorous with trunk, uppermost ray and several lower rays more or less distinctly banded with whitish and tan; extreme tips of rays whitish, translucent. Ventral rays concolorous with body nearby; caudal about concolorous with anal; darker brownish in outer two-fifths, still darker, approaching black, at upper and lower borders; a narrow lighter bar across middle half dozen rays at distal four-fifths of length of fin.

Specimen (*b*). Ground colour throughout medium grey, liberally sprinkled with midbrown markings in the form of some four score spots, most more or less rounded, and a few larger irregular patches, spots on head tending to be smaller; some areas of much lighter grey, including one, the most conspicuous, behind head by about postorbital head, four times as far from ventral as from dorsal profile, and a pair, somewhat smaller, about above termination of anal; a small conspicuous white spot immediately in advance of the lower of the two light grey markings, and, on right side only, a whitish spot in advance of upper. Elevated portion of spinous dorsal chiefly dark, almost black; free tips of spines grey sprinkled with white: membrane in rest of fin dark grey with diffuse peppering of pink and white, and, usually, one more or less central pink splash between adjoining spines. Anterior two-thirds, or so, of soft dorsal whitish or pinkish, heavily punctulated with purplish; elevated posterior section similar in distal half to anterior, dark grey basally; a black patch near tips of longest two rays; tips of all rays briefly white. Anal warm dark brown; a sprinkling, particularly proximally, of very small touches of white provided by minute papillae; ends of rays light grey. Pectoral very dark brown, with several streaks, most marked on upper ray and lower three or four rays, and splashes of lighter, where a number of papillae, elsewhere more or less concolorous with membrane, are dead white, this white extending forward ventrally across base of fin to opercular border; pointed free tips of rays variable, mostly banded with brown and grey, sometimes hyaline. Ventral rays obscurely banded brown and grey. Caudal chiefly greyish, in places with a suggestion of pinkish, heavily punctulated with reddish brown; three arcs of dark brown, the proximal involving only five or six inner rays, the next, well developed, near middle of length of fin, almost black on lowest ray; the distal marking less continuous, including a black spot near tips of two lower rays; a dark spot near end of three middle rays; several small spots and patches of white or whitish on outer one-sixth of fin; free tips of all rays hyaline or whitish.

Fin patterns

The lengths of the dorsal spines and rays, anal rays, pectoral rays, pelvic spine and rays, are all found to exhibit the relation $L = bN^k$, or $L = bN^{1(k)}$, or a combination of these (N being serial number, in the set, of spine or ray, counting caudad, or, in pectoral, downward; N^1 counting cephalad, or, in pectoral, upward).

(*a*) Dorsal spines. The length-number relations are exceptional in being different in the two specimens (see Discussion, below); moreover each pattern is an unusual one. In the 1975 fish the three sets — {I-III}, {IV-X}, {XI-XIII} — all involve N, and k is negative: in the 1942 fish the 1st spine is shorter than the 2nd (giving a graphically trivial set of {I-II}), while of the remaining sets — {II-V}, {VI-VIII}, {IX-XIV}— the first two involve N^1, the third N, all values of k being positive.

The equations, in logarithmic form, are, 1975, $\log 1 = -0.1024 \log N + 1.467$, $\log L = -0.2205 \log N + 0.8701$, $\log L = -0.08838 \log N + 0.6424$; t 19.801*, 15.247***, 8.201*: 1942, $\log L = 0.3888 \log N^1 + 0.0375$, $\log L = 0.1365 \log N^1 + 0.9400$, $\log L = 0.1391 \log N + 0.9530$; t 22.450**, 28.861***, 40.565***. Predicted (measured) lengths, 1975, 14.0 (14.0, 13.1 (13.1), 12.6 (12.5); 7.4 (7.6, 6.4 (6.1)

5.8 (5.9), 5.5 (5.4), 5.2 (5.2), 5.0 (5.0), 4.8 (4.9); 4.4 (4.4), 4.1 (4.1), 4.0 (4.0): 1942, [1st spine 18.5]; 18.7 (19.0), 16.7 (16.5), 14.3 (14.1), 10.9 (11.0); 10.1 (10.1), 9.6 (9.6), 8.7 (8.7); 9.0 (9.0), 9.9 (9.8), 10.4 (10.5), 10.9 (10.9), 11.2 (11.2), 11.5 (11.5) — the lengths of the spines thus decreasing from 1st to 13th in the 1975 specimen, whereas in the 1942 specimen they increase from 1st to 2nd, decrease to 8th, increase to 14th.

(*b*) Dorsal rays. The basic pattern is a common one, a long anterior section of rays of increasing length, graphable against N, followed by a shorter section of decreasing length, graphable against N^1. However, two points call for notice: in the 1942 specimen a slight notch occurs at the 11th ray, which thus lies outside the two main sets {1-10}, {12-16}; in the 1975 specimen, of the two sets {1-10}, {11-15} the former, while yielding a linear graph (slope 0.2002, intercept 0.7664) with a high degree of significance (t = 14.433***), with predicted lengths differing from measured lengths by only 1.1-4.1, mean 2.0 percent, can be more precisely specified by being treated as two sections, {1-4}, {5-10}. Values of k for the 1942 fish are 0.1673, 0.5324, of log b 1.07462, 0.9909; t 99.177***, 6.343**; predicted (measured) lengths of rays 1-10, 12-16, 11.9 (12.0), 13.3 (13.0), 14.2 (14.5), 15.0 (15.0), 15.5 (15.4), 16.0 (16.1), 16.4 (16.5), 16.8 (16.8), 17.2 (17.1), 17.5 (17.5); 18.8 (19.2), 16.7 (16.6), 14.3, (14.5), 11.5 (11.2), 8.0, (7.9). Parameters for sets {1-4}, {5-10}, {11-15} of the 1975 fish are 0.1606, 0.09886, 0.3820 and 0.7771, 0.8942, 0.7779; t 6.311*, 19.303***, 24.118***; predicted (measured) lengths 6.0 (5.9), 6.7 (6.9), 7.1 (7.1), 7.5 (7.4); 7.8 (7.9), 8.5 (8.3), 8.7 (8.7), 9.0 (9.0), 9.2 (9.2), 9.4 (9.4), 11.1 (10.9), 10.2 (10.2), 9.1 (9.2), 7.8 (8.0), 6.0 (5.9).

(*c*) Anal rays. These have been examined only in the more readily measurable individual. The simple pattern has three components, {1-8}, length increasing, N; {9-12}, length increasing, N; {13-15}, length decreasing, N^1. Slopes of the graphs are 0.4392, 0.06131, 0.5370; intercepts 0.6912, 1.1317, 0.8568; t = 33.932***, 7.816*, 103.013***; predicted (measured) lengths 4.9 (4.9), 6.6 (6.6), 7.9 (8.1), 9.0 (8.9), 10.0 (10.0), 10.8 (11.0) 11.5 (11.5), 12.2 (12.1). 13.5 (13.6), 14.1 (14.0), 14.5 (14.5), 14.7 (14.8), 13.0 (13.0), 10.4 (10.4), 7.2 (7.2).

(*d*) Pectoral rays. The two specimens have the same pectoral pattern, a usual one, with one ascending set on N (1st ray uppermost), and more than one set (here two sets) descending on N^1; the sets being {1-4}, {5-7}, {8-11}.

Values (left fin measured) of k, 1942, 0.4256, 0.1092, 0.4419; 1975, 0.4773, 0.1456 0.7915: of log b, 1942, 1.2823, 1.4694, 1.1066; 1975, 1.0814, 1.2767, 0.7653; t, 1942, 24.707**, 8.813, 36.339***; 1975, 51.979***, 118.536**, 35.117***. Values of $\widetilde{L}(L)$, 1942 , 19.2 (19.0), 25.7 (26.0), 30.6 (31.0), 34.6 (34.0), 33.2 (33.1), 31.8 (32.0), 29.5 (29.4); 23.6 (23.4), 20.8 (21.1), 17.4 (17.2), 12.8 (12.8); 1975, 12.1 (12.0), 16.8 (16.9), 20.3 (20.4), 23.3 (23.1); 22.2 (22.3), 20.2 (21.0), 18.9 (19.0); 17.5 (17.6), 13.9 (14.0), 10.1 (9.8), 5.8 (5.9).

(*e*) Ventral spine and rays. The lengths of the spine (covered with integument, closely bound throughout its length to the adjacent ray; readily distinguishable in the larger individual, traceable with difficulty in the smaller), the ray flanked by spine and ray (adherent to the ray for some four fifths of its length) and the inner ray exhibit a progressive increase of the exponential character encountered in other fins or sections of fins. Since the inner or immediately postaxial ray (that furthest from spine) is by convention (Part XIX, 1974a, p.294) treated as the first element of the fin, the relation between length and serial number assumes the form $L = bN^{1(k)}$. For the 1942 specimen the equation, in logarithmic form is, log L = 0.3545 log N^1 + 1.0728, for the smaller example log L = *0.2710 log* N^1 + 0.9250; t being 21.347*, 31.490**. Predicted (measured) lengths (spine first) are, 1942, 17.5 (17.4), 15.1 (15.2), 11.8 (11.8); 1975, 8.4 (8.4), 10.2 (10.2), 11.3 (11.3).

Discussion

The lastest available account of the species – that of Scott *et al.* (1974, p.184, fig. on p.184 after Richardson) –recognized two subspecies of *A. milesii*, the typical subspecies, *A. m. milesii* (Macleay, 1881), occurring in Western Australia, South Australia, Tasmania, and *A.m. horrenda* Whitley, 1935, found in New South Wales and Victoria.

The comparison below is based on the following sources: in respect of *A. m. horrenda* on Whitley's diagnosis of his subspecies and his figure (1933, pl.13, fig.3) of a New South Wales example (with, in parentheses, some contrasting specifications, from the same paper, of the typical subspecies); in respect of *A. m. milesii* Richardson's original description of *Aploactis milesii* and his figure of the type – reproduced in various sectional Australian catalogues, *e.g.*, those of Waite (1923), McCulloch (1922), Scott (1962), Scott *et al.* (1974) – Castelnau's 1873 account (as *Aploactisoma schomburgkii*) of the very briefly described *A. schomburgki* Castelnau, 1872, from St Vincent's Gulf, South Australia, Scott *et al.* (1974, p.184, and figure after Richardson), and our two Tasmanian fish. For each of the four diagnostic features ascribed to it, *A. m. horrenda* is specified first in the notes below.

'Body deeper': from figure maximum depth about 4, depth at vent about $4^1/_3$, in *Lt.* In *A. m. milesii* 'the height of the body nearly one-fourth of the total length, caudal included' (Richardson), and from his figure maximum depth about $4^3/_4$, depth at vent about 6, in *Lt*; 'height contained four times in the total length' (Castelnau); our specimens, corresponding measurements, (*a*) 4.3, 4.6, (*b*) 3.9 (gravid), 4.8.

'Villi blunt' (contrast 'fine-pointed'). Our specimens, (*a*) slender, length modally 5-7 times basal diameter, slightly tapered, with fine point, (*b*) (in the original account of (*b*) (Scott, 1942) the villi were assessed, in the absence of comparative material, as 'fine'; they are, indeed, pointed, but compared with those of the 1975 example they are seen to be gross).

'Size larger, up to nearly 7 inches', about 180 mm (contrast 'to five inches', about 130 mm). Size of type of *A. milesii* not specified; 'two specimens, the longest of which measures five inches, but Mr Waterhouse tells me he has one almost twice that size' (Castelnau); 'length to 23 cm' (Scott *et al.*); our specimens, (*a*) 75, (*b*) 130 mm.

'Colour more uniform and dark brownish' (contrast 'the prevailing tone of spirit specimens brown, with indistinct darker spots and marblings of purple and whitish, with anterior dorsal fin dusky'). In the type of *A. milesii* 'The only vestiges of colour remaining in the dried specimen are brown and purple bands and blotches on the dorsal, caudal and pectoral, with one or two rows of white spots on the two latter fins'; 'the colour is of a dark brown marbled with black; there is a spot of that colour at the posterior angle of the second dorsal, and the caudal and anal are bordered with the same' (Castelnau); 'Colour brown, with darker spots, the tips of the papillae reddish or orange' (Scott *et al.*); colours of our specimens, described above, differ considerably – judged by the criterion 'colour more uniform' (*b*) would appear to qualify as *A. m. horrenda*, but judged by its lighter coloration as *A. m. milesii*, while the more variegated appearance of (*a*) would identify it as *A. m. milesii* but its quite dark brown perhaps as *A. m. horrenda*.

There is a very marked difference in the general visual character of the integument in our two fish, that of (*b*) being seemingly much thicker and appearing to be of a somewhat rubber-like consistency, that of (*a*) being apparently thinner and more of a membranous nature: while it is evidently not possible satisfactorily to determine the tactile properties of an integument of figured specimens, inspection of the illustrations of Richardson and Whitley leaves an impression that the former is more compatible with (*b*), the latter more compatible with (*a*).

While a definitive judgement must wait on an examination of a good range of comparative material, it would nevertheless appear from the foregoing analysis of available

data that the existence of distinct geographical forms of the species is much to be doubted.

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NOTE ADDED IN PRESS

Reference is made on pages 157, 162 and 163 to specimens of *Alabes parvulus* McCulloch, 1929 from Greens Beach, northern Tasmania, as constituting the first record of the species from this state. On 27th September, 1976, while the present paper was in the press, a copy was received of an important paper which reports *A. parvulus* from Coles Bay, east coast, Tasmania. A new species, *A. hoesei* (differing in having two postocular sensory canal pores instead of one) is described from the same locality, also from S.A. and N.S.W. The reference is:

Springer, V.G. and Fraser, T.H., 1976: Synonomy of the fish families Cheilobranchidae (=Alabetidae) and Gobiesocidae, with descriptions of two new species of *Alabes*. *Smithsonian Contribs to Zoology*, 234.

PAPERS AND PROCEEDINGS OF

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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA

VOLUME 111

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ROYAL SOCIETY OF TASMANIA

ANNUAL REPORT FOR THE YEAR 1976

The Council has the honour to present to members the following report on the activities of the Society during the year.

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Dr M.R. Banks

PRESIDENT

Sir Stanley Burbury, took the Chair, as President of the Society, at the General Meetings in June and December.

ROYAL SOCIETY OF TASMANIA MEDAL

At a Special General Meeting in December, the President presented the Royal Society of Tasmania Medal to Dr Donald Martin in recognition of prolonged research of high merit.

Previous recipients of the medal have been:

1970	D.L. Serventy
1940	W.E.L. Crowther and V.V. Hickman
1935	A.N. Lewis
1934	H.H. Scott
1930	Clive Lord
1927	L. Rodway

ANNUAL MEETING

At the Annual Meeting on 4 March, Mr A.R. Neilson retired as Vice-President, and Mr M.R. Banks and Mr R.J. Downie as Members of the Council. The following were elected -

Vice-President	-	Mr K.E.J. Robinson
Members of Council	-	Mr R.J. Downie
	-	Mr A.R. Neilson
Honorary Secretary	-	Mr D.R. Gregg
Honorary Treasurer	-	Mr G.E.A. Hale
Honorary Auditor	-	Mr D.B. Churchill

LECTURES

The following lectures were given in Hobart during the year -

March	"Old Beach Bones"	Mr M.R. Banks, University of Tasmania
April	"Devils at Granville Harbour"	Dr E.R. Guiler, University of Tasmania
May	"The Vital Roll of Food: Source of Nutrients and Delights"	Professor Z.E. Sikorski, Department of Food Preservation, Technological University Politechnika, Gdanska, Poland, and Visiting Research Fellow at CSIRO, Hobart
June	"Implants in Surgery"	Professor R.M. Mitchell, University of Tasmania
July	"Brick and Stone Decay in the Penal Settlement at Port Arthur"	Dr N.K. Roberts, University of Tasmania
August	"John Glover, Landscape Painter - Romanticism or Reality?"	Mr John McPhee, Queen Victoria Museum and Art Gallery, Launceston
September	"Australian Cities and Public Policy"	Professor P. Scott, University of Tasmania
October	"A Word-list of the Tasmanian Aboriginal Languages"	Mr N.J.B. Plomley, Launceston
December	"Early Tasmanian Horticulture"	Dr D. Martin

QUEENSTOWN SYMPOSIUM

A symposium - "Landscape and Man - the Interaction between Man and the Environment" - was held at Queenstown on Saturday, 30 October to Monday, 1 November 1976, and took the place of the November General Meeting of the Society. The Society is indebted to the Mt Lyell Mining and Railway Company for the assistance provided by the company in making available staff and facilities during the symposium. Seventy people attended. Proceedings opened with an address "A Pummelled Landscape" by Professor G. Blainey. Subsequently speakers from Government departments, the University of Tasmania and industries made contributions on many aspects of the natural history and resources of the region and their utilisation. Proceedings closed with an address by Professor P. Scott on "The Future". Excursions were held in conjunction with the symposium - a half day excursion to Strahan attended by 6 people, a day excursion to the summit of Mt Read attended by 36 people and a day excursion to Granville Harbour (9 participants). The excursions were lead by Dr M.R. Banks, Dr J. Kirkpatrick, and Dr E.R. Guiler.

The Council is grateful to the committee who organised the symposium and in particular to Dr Banks.

NORTHERN BRANCH

The Northern Branch of the Society based in Launceston had the following Council -

Chairman	-	Mr P.G. Webb
Vice-Chairman	-	Mr H.S. Payne
Past Chairman	-	Dr E.V.R. Ratcliff
Honorary Secretary	-	Mr T.E. Burns
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Members	-	Mr G.H. Stancombe
	-	Mr N.J.B. Plomley
	-	Mr K.E.J. Robinson
	-	Mr H.C.A. Pitt
	-	Mr David F. Smith

Mr D. Walter was co-opted as Excursion Organiser.
Mr J.N. Gee was appointed Auditor and
Mr K.E.J. Robinson relieving Treasurer.

The following lectures were given -

March	"How to be Happy though Provincial"	Dr E.V.R. Ratcliff
April	"Aspects of Town Planning in Launceston"	Mr T. Kneebone
May	A Tour of the Newnham Campus of the T.C.A.E.	Dr David F. Smith
June	"Some Aspects of Indonesian Education"	Mrs M. Dowse
July	"The Troublemakers"	Mr G.H. Stancombe
August	"A Tour of the Northern Regional Library"	Mr P.F.J. Leonard
September	"Fish Technology: A Diversified Profession"	Dr J.N. Olley
October	"Nature Conservation in Tasmania"	Dr I.H. Eberhard
November	"Pre-settlement History of Mid-Devon"	Mr B.M. Thomas
December	Members' Night "Golf"	Mrs Gwen Wales née Tilley by means of a tape made available by Mr S.V. Tilley
	"Across the Gibson Desert"	Mrs Z. Rosen
	"Banjo Paterson"	Mr Ron Ward
	"Features of Old Tasmanian Houses"	Mr A.T. Orr
	"A Great Tasmanian Poet"	Mr H.S. Payne

On 15 September, Branch members were the guests of the Tasmanian Historical Research Association when Dr R. Wettenhall delivered the Eldershaw Lecture on Public Administration in Australia.

An excursion visited the St Leonards area in May, under the guidance of Mr Stancombe, and in April there was a Tamar River cruise on the *Goondooloo*.

PUBLICATIONS

Volume 110 of the Papers and Proceedings was published early in December 1976. It contained 12 papers, totalling 217 pages, including papers on several aspects of botany, zoology, geology and one on psychiatry.

Preparation of Volume 111 is well advanced.

Preparation of the proceedings of the Queenstown Symposium is almost complete.

The Society is indebted to Dr Banks for his continuing work as Honorary Editor.

MEMBERSHIP

During the year the membership was 536 a decrease of 15.

The membership is made up as follows -

	Northern Branch	Total
Honorary Life Members	1	6
Life Members	9	34
Ordinary Members, receiving Papers and Proceedings	90	278
Ordinary Members, not receiving Papers and Proceedings	108	191
Associate Members	19	27
	227	536

COUNCIL MEETINGS

The Council met four times during the year with Mr G.H. Stancombe and Mr P. G. Webb representing the Northern Branch on the Council.

One meeting of the Council, on 3 September, was held in Launceston, the first time the Council had met outside Hobart since 1965.

NOMINEES TO OTHER BODIES

The Council re-elected Mr M.R. Banks and Dr D. Martin to the Board of Trustees of the Tasmanian Museum and Art Gallery. They report on the year's activities as follows:

> The Tasmanian Museum and Art Gallery has continued to collect, preserve, study and exhibit objects related to the natural and human heritage of Tasmania, together with relevant material from beyond the State.
>
> Shortage of space, both for reference collections and for display, is becoming of increasing concern to the Trustees. It is hoped that, before long, Commonwealth buildings adjacent to the present site will be made available to permit the further development of the Museum and Art Gallery.

An important acquisition during the year was a portrait thought to be of Abel Janszoon Tasman, the European discoverer of Tasmania. This portrait was purchased in London by the Tasmanian Government and presented to the Trustees.

An Art Conservation Workshop has been set up as a joint project with the State Library of Tasmania and is doing valuable work in preserving paintings of great historical and artistic interest.

The major exhibition shown during the year was *The Tasmanian Aboriginal in Art* which assembled in one place for the first time the main pictorial records of the Tasmanian Aboriginals.

The status of the Royal Society within the Museum seems safe for the present although there is the possibility of a major re-organisation of museums in Tasmania. This would require legislation and presumably the opportunity to safeguard our position.

The Council re-elected Dr M.H. Hurburgh to the Board of Trustees of the Royal Tasmanian Botanical Gardens. He reports on the year's activities as follows:

Many improvements have occured in the Royal Tasmanian Botanical Gardens during the last twelve months.

Mr A.P. May, the new superintendent, has been responsible for a vigorous planting-out programme, particularly in the more recently developed northern end of the Gardens where emphasis has been placed on the planting of indigenous species.

The R.E.D. Scheme also helped greatly towards the general improvement of the Gardens.

Under the aegis of the Australian Biological Resources Study Interim Council, the Tasmanian Herbarium had the service of Mr J.W. Parham, a noted botanist, as curator of the Tasmanian Herbarium project. During his term of office much valuable work was done under difficult conditions and his reports should provide invaluable material for the future development of the Herbarium.

ACKNOWLEDGEMENTS

The Council is grateful for help generously given by many individuals and organisations. In particular, the lecturers, the Government of Tasmania, the University of Tasmania, the Tasmanian Museum and Art Gallery, and the Queen Victoria Museum and Art Gallery are specially thanked for their help and co-operation.

ROYAL SOCIETY OF TASMANIA

Balance Sheet as at 31 December 1976

1975			1976	1975		1976
65 028	Accumulated Funds		81 208.01	20	Cash on hand	33.00
51	Subscriptions in Advance		30.00	4 651	Cash at Bank - General Account	1 715.18
	Trust Funds -				- Papers and Proceedings	
	Clive Lord Memorial			6 519	Account	5 752.42
1 081	Fund	1 176.61		532	- Publications Account	-
	A.N. Lewis Memorial			380	- Clive Lord Memorial Account	476.61
1 657	Fund	1 760.81		557	- A.N. Lewis Memorial Fund	660.81
	Morton Allport			860	Mortgage Loan - Perpetual Trustees	860.00
710	Memorial Fund	765.98			Commonwealth Treasury Bond and	
317	A. Clark Bequest	329.27		10 430	Inscribed Stock (at cost)	10 430.00
	Joseph Milligan			-	Interest Bearing Deposits	7 000.00
2 121	Bequest	2 235.87		15 000	Library (at valuation for insurance)	15 000.00
1 056	R.M. Johnston				Stock of Publications on Hand (at selling	
	Memorial Fund	1 145.74		36 500	prices)	50 300.00
481	Henry Oliver Bequest	502.99				
	W.H. Hudspeth					
1 222	Memorial Fund	1 269.77				
1 725	Life Membership Fund	1 802.97	10 990.01			
$75 449			$92 228.02	$75 449		$92 228.02

In my opinion the attached Balance Sheet, Accumulation Account and Statements of Receipts and Payments for the General Account and Papers and Proceedings Account, are properly drawn up so as to give a true and fair view of the state of affairs of the Royal Society of Tasmania as at 31 December 1976 according to the books and records produced to me. The value of the Library and Stock of Publications on hand is accepted at the valuation as stated in the Balance Sheet having been submitted to me by the Royal Society of Tasmania.

23 February 1977

D.B. Churchill, F.A.S.A.
Licenced Auditor

ROYAL SOCIETY OF TASMANIA

GENERAL ACCOUNT TO 31 DECEMBER 1976

Receipts			Payments	
Carried forward from 1975		4650.83	Stationery	43.95
Subscriptions -			Insurance	170.65
2 @ $100	200.00		Attendants' fees	463.51
214 @ $8	1712.00		Library expenses	306.38
126 @ $5	730.00		Accounting expenses - Layh, Hart, Room & Hyland	352.50
21 @ $3	63.00		Meetings	435.32
Other years	232.68	2937.68	Petty Cash	130.00
Interest on Special Accounts		632.06	Return of Cheques	13.00
Sales of publications		853.79	Management Fee, University of Tasmania	1450.00
Government Grant		1450.00	Post Office Box Fee	102.00
Rent		390.90	Postage	156.40
Closure of Publications account		588.13	Payment to Life Membership Fund	200.00
Queenstown Symposium		3665.00	Purchase of interest bearing deposits	4000.00
Miscellaneous		45.76	Typing expenses	76.25
			Mileage	67.56
			Payment to Northern Branch	1146.00
			Photocopying	8.02
			Catering for supper - Roy. Soc. Medal present.	40.00
			Cheque Book	8.00
			Payment to Papers & Proceedings Account	869.04
			Expenses Queenstown Symposium	3460.39
				13498.97
			Balance in bank	1715.18
		$ 15214.15		$ 15214.15

PAPERS AND PROCEEDINGS ACCOUNT TO 31 DECEMBER 1976

Receipts		Payments	
Brought forward from 1975	6519.07	Government Printer - Volume 109	1359.85
Interest from investments	774.43	University of Tas - postage	31.20
Sales of publications - Papers and Proceedings	716.36	Australia Post - postage	12.00
Transfer from General Account	869.04	Purchase of Interest Bearing Dep.	3000.00
Miscellaneous publications sales	8.15	Cheque Book	2.40
Payment to Life Membership Fund	200.00	Macquarie Typing Service - Volume 110	915.42
University of Tasmania Grant to Papers and Proceedings	2000.00	M.R. Banks - photocopying	13.74
		Total	5334.61
		Balance in Bank	5752.44
	$ 11087.05		$ 11087.05

ROYAL SOCIETY OF TASMANIA

YEAR ENDED 31 DECEMBER 1976

Accumulation Account

Balance per Accounts 1 January 1975		65 028.21
Plus Stock adjusted	13 800.00	
Subs in Advance adjusted	21.00	
Income Publications Account	55.93	
Cash on hand adjusted	13.00	13 889.93
		78 918.14
Plus Excess Receipts over Expenditure		2 709.59
		81 627.73
Less Transfers to Trust Funds		419.70
Balance 31 December 1976		$ 81 208.03

Papers and Proceedings of the Royal Society of Tasmania, Volume 111, 1977.

(ms. received 30.9.1976)

A SEQUENCE OF LATE QUATERNARY DEPOSITS AT PIPE CLAY LAGOON, SOUTHEASTERN TASMANIA

by Eric A. Colhoun
Department of Geography, University of Tasmania

(with three tables, five text-figures and two plates)

ABSTRACT

A record is presented of late Quaternary deposits from two sections on the Lumeah Point Peninsula, Pipe Clay Lagoon. The results permit interpretation of some of the main geomorphic events and environmental changes that have occurred during the late Last Glacial and Holocene stages.

Interglacial marine deposits of sand, clayey-sand and gravels are unconformably overlain by freshwater organic sediments dated to about 25,000-20,000 BP. Pollen analysis indicates a change in vegetation from *Eucalyptus* forest to *Eucalyptus*-savannah during this time. After 22,000 BP aeolian sands began to accumulate at Site A and probably continued during the maximum of the Last Glacial stage. Once stabilised, the aeolian and adjacent marine sands were strongly podzolised during the Holocene. Aboriginal middens and thin coversands resulting from forest clearance for agriculture by European settlers occur in and on the A_1 horizon of the podzol.

INTRODUCTION

The South Arm is formed by a series of low hills composed of Permian sandstones and mudstones which are locally intruded by masses of Jurassic dolerite. The low hills of the eastern part of the peninsula are separated from those of the western part by a small graben, the southern portion of which is flooded by the sea to a depth of 1-3 m in Pipe Clay Lagoon, southwest of Cremorne (fig. 1.) The graben is floored with sands, clays and ironstones of Tertiary age (Green 1961).

The low hills have been linked by terraces of marine and aeolian sediments of Late Quaternary age to form the present peninsula. Davies (1959) recognised the presence of a 4-5 m marine terrace in southeastern Tasmania which he named the *Llanherne Level* and assigned to the Last Interglacial stage. This level is widely represented in South Arm and is associated with other higher terraces of marine deposits at levels up to at least 21-22 m which are considered to be of Last Interglacial age.

The surfaces of these marine terraces are not everywhere flat or gently sloping but are locally interrupted by both shallow (< 5 m) and deep (> 5 m) deflation hollows. Some of these hollows are occupied by lagoons and a few, such as Rushy Lagoon, are flanked on their leeward sides by lunettes.

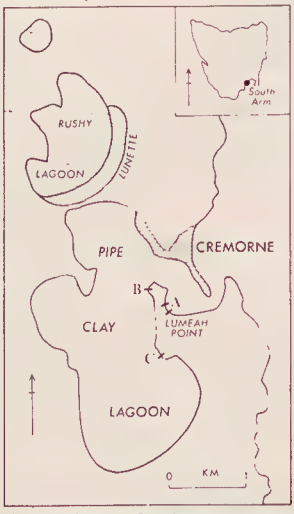

FIG. 1 - Location of Pipe Clay Lagoon and the Lumeah Point Peninsula

Late Quaternary Deposits at Pipe Clay Lagoon

The lagoons and lunettes of South Arm are generally considered to be of Last Glacial age. They are formed in and from marine deposits of Last Interglacial age.

In late 1972 an important section was found at Site A (figures 1 and 2) on the low peninsula of Lumeah Point (Lat. 42°55' S., Long. 147°34' E.) which extends northwards into Pipe Clay Lagoon and has an undulating surface between 3-4 m above OHWM. The section revealed a sequence of Late Quaternary marine, freshwater and aeolian sediments which when considered with other deposits exposed by marine erosion on the western side of Lumeah Point (Section B-C, fig. 3) help to date the development of the deflation hollows and to elucidate some of the environmental changes experienced in South Arm during the Last Glacial stage. It is the purpose of this paper to record and interpret the sequence of Late Quaternary deposits exposed on the Lumeah Point peninsula and to discuss some of the implications of the inferred environmental changes.

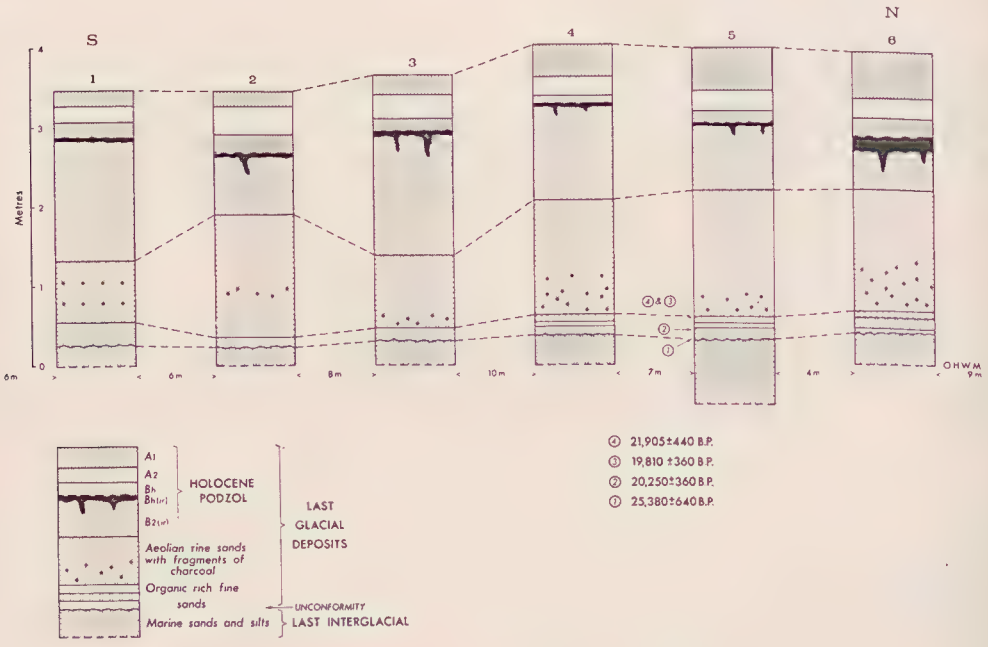

FIG. 2 - Stratigraphy of deposits at Site A

STRATIGRAPHY OF SITE A

The sequence of deposits exposed at Site A is summarised in figure 2 which owing to slumping of the cliffline has been drawn as six profiles. The profiles are numbered from south to north with the intervening distances given in metres and the continuity of units shown by dashed lines. The sequence consists of four sedimentary units, a strongly developed soil profile, and at least one unconformity (plate 1.)

The basal unit consists of beds of greenish-grey (Standard Soil Color Charts (1967); moist condition.) sandy-clay with dark olive mottles, fragments of rotted dolerite up to 5 mm diameter, and beds of grey and greyish-olive well rounded medium

PLATE 1 - Site A showing freshwater deposits, aeolian sands and deep podzol profile

PLATE 2 - Site A showing freshwater organic deposits and aeolian sands overlying interglacial marine sands. Note laminated structure of the upper organic sands.

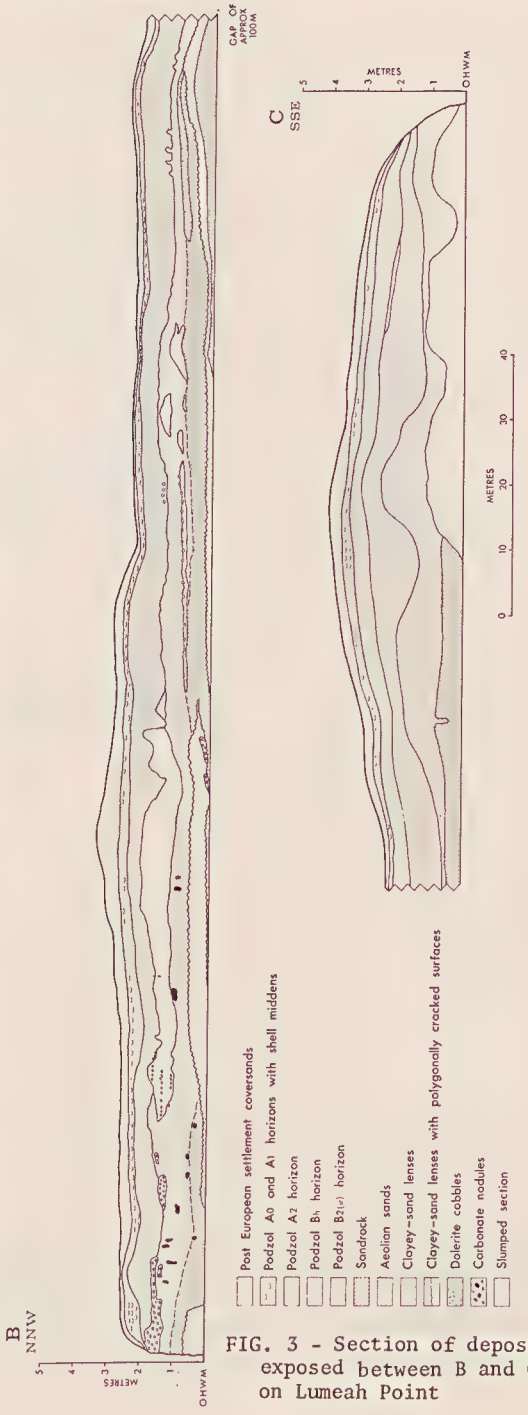

FIG. 3 - Section of deposits exposed between B and C on Lumeah Point

grade beach sands. These deposits are of marine origin and extend from a depth of more than 0.62 m below OHWM as determined by augering in profile 5 to 0.46 m in profile 6. They are mainly composed of granules, coarse and medium sand (table 1.). The beds of sandy-clay with dark olive mottles have resulted from the mixing of the marine sands with rotted dolerite clay and weathered rock fragments that existed prior to the marine transgression across this site.

A marine platform cut in dolerite probably occurs at shallow depth. This suggestion is based on water borings made immediately behind the site which reached weathered dolerite clay at between 3-4 m depth. It is also supported by the presence of a fossil platform cut in dolerite which passes beneath the marine sands at the northern end of Lumeah Point. The marine deposits at Site A have no free carbonates and a negligible organic carbon content of 0.47 per cent by weight; a value probably attributable to slight organic enrichment from the overlying beds and possibly a trace of moisture expelled during dry combustion. (Organic carbon determined by weight loss on dry combustion for 16 hours at 500° C.).

The marine deposits are strongly gleyed and pass upwards into black highly humified organic enriched (14.4% organic carbon) clayey-sand deposits that vary from 60-140 mm in thickness (plate 2). Samples were taken from this horizon in profile 5 at 310-360 mm and at 390-440 mm for ^{14}C dating. Samples were also taken at 330-340 mm, 370-380 mm and 420-430 mm for pollen analysis (fig. 4).

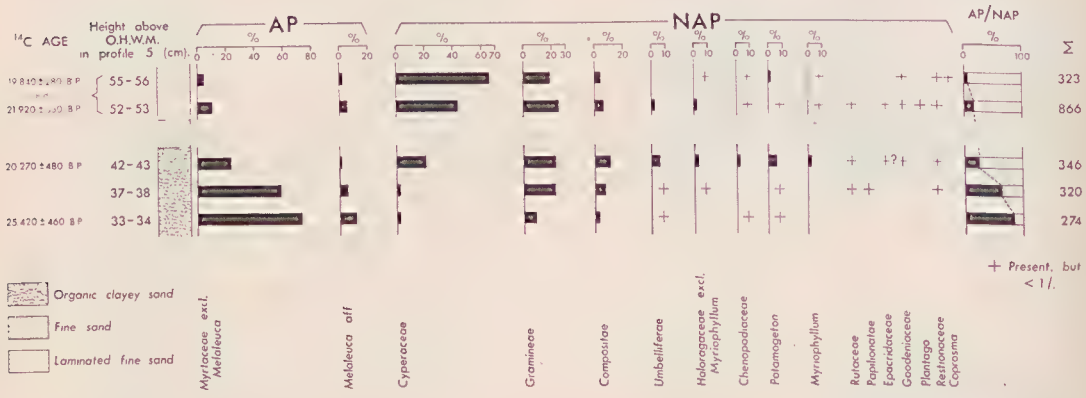

FIG. 4 - Pollen spectra from the organic deposits at Site A

This stratum is succeeded in profiles 4 to 6 by a thin bed of greyish yellow-brown, unconsolidated, aeolian fine sand, with small specks of charcoal, which varies from 40-120 mm in thickness. This bed lenses out southwards and disappears between profiles 4 and 3.

In profiles 4 to 6 the aeolian sand is overlain by black organic horizons that are separated by laminae of aeolian fine sand which together have an organic carbon content of 9.2 per cent. The alternate lamination of the organic horizons and aeolian sand indicates periodic production and accumulation of organic materials in the shallow pond or marshy depression while sand was being blown across the area. A sample was taken in profile 5 at 0.52-0.56 m above OHWM for ^{14}C dating and samples were taken at 0.52-0.53 m and 0.55-0.56 m for pollen analysis (fig. 4).

TABLE 1

CHARACTERISTICS OF SEDIMENTS AT SITE A, PIPE CLAY LAGOON

Sample	Stratum	Location of sample in profile 4 above OHWM	Colour[1]	Granules % > - 1ø	Coarse Sand % < 1ø >1ø	Med. sand % < 1ø > 2ø	Fine Sand % < 2ø > 4ø	Silt & Clay % < 4ø	pH	Organic Carbon % weight
1	A_1 horizon	3.85 m	Brownish-grey 7.5YR 5/1	0.0	0.0(Tr.)[2]	2.6	94.5	2.3	3.5-5.5	11.9
2	A_2 horizon	3.5 m	Brownish-grey to greyish-brown 5YR 6/1-2	0.0	0.0	4.8	93.8	1.4	3.5-4.0	0.9
3	B_h horizon	3.33 m	Dull reddish brown 5YR 5/4	0.0	0.0	3.0	96.5	0.5	4.0	1.0
4	$B_{h(ir)}$ horizon	3.26 m	Reddish-black 2.5YR 2/1	0.0	0.0	2.5	96.0	1.2	4.0	3.7
5	$B_{2(ir)}$ horizon	2.98 m	Yellowish-brown 10YR 5/6	0.0	0.0	3.2	96.4	0.4	7.0	1.7
6	$B_{2(ir)}$ horizon	2.18 m	Bright yellowish-brown 10YR 6/6	0.0	0.0	4.4	95.2	0.4	6.5	0.6
7	Aeolian sands	1.10 m	Light grey to light yellow/orange 2.5YR 8/2-3 to 10YR 8/4	0.0	0.0	1.4	98.0	0.6	7.0	0.3
8	Organic sands	0.58 m	Black to dull yellow 10YR 2/1 to 2.5YR 6/3	0.0	0.0(Tr.)	0.8	95.5	3.5	7.0	9.2
9	Organic clayey-sand	0.43 m	Black 10YR 1.7/1	0.0	1.2	20.6	40.5	36.2	6.5	14.4
10	Marine Sands	0.20 m	Greyish-olive 5YR 6/2	0.3	3.1	41.8	46.9	7.8	6.5-7.0	0.4

[1]Standard Soil Color Chart; moist condition

[2] (Tr.) Trace < 0.1 %

This unit of laminated organic materials and aeolian sands is succeeded by 2 m to 2.5 m of cross-bedded aeolian fine sands. Above the winter watertable, which occurs at 0.9 m, these sands vary in colour from pale yellow through yellowish-brown to brown with increasing degrees of iron oxidation. Below the watertable the aeolian fine sand is dull brown in colour. The aeolian sand is well sorted with approximately 95 per cent or more of samples from all horizons (table 1, samples 1-8) consisting of fine sand. The deposit contains numerous small fragments of charcoal of 1-3 mm size which are mainly dispersed throughout the lower unoxidised part of the deposit, but in profiles 1 and 2 the charcoal fragments occur within the cross-bedded structures and indicate that they were blown into the depression with the sand. The average strike of the cross-beds and their southeasterly dip indicates that the winds which filled the hollow with sand blew predominantly from the northwest which is also the present prevalent wind direction. The fine sand of the infill was derived from the fine marine sands that form most of the Lumeah Point peninsula west and northwest of Site A and comprise the main sedimentary unit represented in Section B-C (fig. 3).

At Site A the upper 0.5 to 1.7 m of aeolian sand has been altered to a podzol soil profile with strongly developed A_1, A_2, B_h, $B_{h(ir)}$ and $B_{2(ir)}$ horizons.

The $B_{2(ir)}$ horizon varies from bright yellowish-brown in colour near its base to brown near its boundary with the $B_{h(ir)}$ horizon. It is moderately cemented in its upper part where in places weak sub-angular peds of 10-40 mm size have been developed. On exposure this horizon rapidly develops a striking honeycomb weathering structure which extends for approximately 0.5 m depth. Below this the $B_{2(ir)}$ horizon is generally weakly cemented, except on several horizons of local iron concentration, and merges with the parent aeolian sand.

The overlying $B_{h(ir)}$ horizon varies from 20-150 mm in thickness with frequent root-like extensions that penetrate the underlying $B_{2(ir)}$ horizon for 100-300 mm depth. This horizon is reddish-black in colour and is strongly cemented with iron and humic materials which latter give this horizon an organic carbon content of 3.7 per cent (table 1.). There is a marked reduction in pH from neutral and near neutral reaction in the $B_{2(ir)}$ horizon and underlying deposits to the strongly acidic values of the $B_{h(ir)}$ and overlying horizons. The surface of the $B_{h(ir)}$ horizon is strongly impacted and is sharply separated from an overlying dull reddish-brown coloured B_h horizon that consists of 100-250 mm of incoherent aeolian fine sands. This horizon is coloured by small amounts of organic carbon and oxidised iron.

The B_h horizon merges with the A_2 horizon which consists predominantly of grey coloured, structureless, aeolian fine sand that is held together only by penetrant fibrous roots. This 250-350 mm A_2 horizon is succeeded by a 200-550 mm thick A_1 horizon composed of brownish-grey, incoherent, aeolian fine sand that is bound loosely by a thick mat of fibrous roots. This horizon contains abundant charcoal and layers of oyster shells that mark former aboriginal midden sites. Locally the A_1 horizon is capped by a very thin (< 50mm) deposit of light yellow-brown aeolian sand which has formed since European settlement of the area.

STRATIGRAPHY OF SECTION B-C

A drawing of the deposits exposed on the western side of the Lumeah Point peninsula was made for the purpose of relating the stratigraphy at Site A to the wider local extent of the 3-4 m marine terrace (fig. 3).

The bulk of the deposits north-northwest of the gap in the section consist of shallow water marine fine sands with extensive lenses of clayey-sand and occasional lenses of weathered dolerite cobbles and ironstone fragments. The deposits resemble those that are currently being formed in the intertidal zone of Pipe Clay Lagoon and the presence of several horizons of polygonal shrinkage cracks on the surfaces of the

lenses of clayey-sand indicate that this formation was also deposited under protected intertidal conditions. The lenses of dolerite cobbles are former accumulations of beach cobbles which confirm that the sedimentary sequence was built up in shallow water during a marine transgression.

Since their deposition these marine sediments have been weakly cemented by iron and humic materials under the influence of soil forming processes that have resulted in podzolisation and under the influence of seasonally fluctuating groundwater tables. This has resulted in the upper parts of the deposits being weakly cemented with illuvial iron and humic materials into distinct $B_{h(ir)}$ and $B_{2(ir)}$ horizons, and the lower parts of the deposit being cemented with iron and humus at and below the water-table and in zones of water perched above the lenses of clayey-sand to form a sandrock. Nodules of carbonate have been developed locally within these marine sands and are from 50-300 mm in diameter.

The uppermost metre of this part of Section B-C is composed chiefly of fine marine sands with granules of ironstone. Locally these fine sands have been redistributed by wind action and the polished ironstone granules have been concentrated into lag-horizons. Locally the surface of the undistributed marine sands exhibits wind-scour flutings.

Both the marine sands and the locally redistributed aeolian sands have been strongly podzolised and exhibit distinct A_1, A_2, $B_{h(ir)}$ and $B_{2(ir)}$ horizons which cut across the marine and aeolian lithological units. The A_1 horizon contains numerous oyster shells and charcoal associated with former aboriginal midden sites. It is overlain by 0.2-0.7 m of yellow-brown aeolian sand which has accumulated since European settlement of the area.

South-southeast of the break in Section B-C the deposits consist entirely of aeolian fine sand which formed a dune (fig. 3). The sand varies from light grey to yellowish-brown and is cemented near its base by iron and humic materials to form a sandrock. The surface of the dune exhibits clearly the A_1, A_2, $B_{2(ir)}$ horizons of a podzol soil and a $B_{h(ir)}$ horizon is locally developed. The greater thickness of the deposits here than in the northeastern part of the section serves to separate clearly the podzol soil profile above from the groundwater podzolised sandrock horizon below. The A_1 horizon of the dune contains shell midden horizons with associated charcoal and is overlain by up to 0.5 m of unconsolidated yellow-brown aeolian sands.

DISCUSSION

The preceding record of the deposits exposed on Lumeah Point shows that a complex series of marine, freshwater and aeolian deposits form the peninsula. When these are considered in association with other information known from South Arm and adjacent areas of southeastern Tasmania it is possible to reconstruct a partial sequence of geomorphic events and environmental changes that have occurred in this locality since the later part of the Last Interglacial.

The burial of the marine platform cut in dolerite on Lumeah Point beneath the sequence of sands which forms most of the peninsula, and the composition and structure of these intertidal deposits, proves that the sea transgressed the graben of Pipe Clay Lagoon and formed the marine terrace that extends to 3-4 m above present OHWM. The deeply weathered nature of the dolerite beach cobbles at the north-northwestern end of Section B-C suggests that the platform and marine deposits were formed during the Last Interglacial stage. Although the field evidence shows that most of the marine sediment was deposited in a protected intertidal environment there are no distinct shoreline features at this site from which to determine the upper limit of transgression.

Late Quaternary Deposits at Pipe Clay Lagoon

These deposits may represent intertidal deposits that accumulated before the maximum transgression level was attained and survived as bay floor sediments when the water became deeper. These shallow water marine deposits are separated by an unconformity from the overlying freshwater and aeolian deposits which accumulated in a depression in the land surface which was 2-3 m deep and more than 60 m wide.

The samples taken for dating from the lower freshwater organic sands and from the upper laminated organic sands in profile 5 gave the following radiocarbon ages:

0.52-0.56 m	19,810 ± 360 BP	(SUA - 153, and
	21,905 ± 440 BP	(SUA - 153/2)
0.39-0.44 m	20,250 ± 360 BP	(SUA - 152)
0.35-0.36 m	25,380 ± 640 BP	(SUA - 151)

When the samples were submitted for ^{14}C dating it was indicated that infinite dates might be obtained and that sample SUA - 153 should be processed first to ascertain if the organic sands were likely to provide finite dates. When the result of 19,810 ± 360 BP (SUA - 153) was found to be considerably younger than expected an assay was carried out on another portion of the same sample after boiling in alkali and washing. This yielded a radiocarbon age of 21,905 ± 440 BP (SUA - 153/2). If the probability limits are examined and the assays are tested using the relationship of the arithmetic difference between the assays and the square root of the sum of the squares of each deviation (Polach and Golson 1966) then it is highly probable that SUA 153/2 differs significantly from SUA - 153. As it is possible that traces of modern humic acid may have decreased the age of SUA - 153 the older date is considered the better.

While the date 20,250 ± 360 BP (SUA - 152) lies between SUA - 153 and SUA - 151 to give a consistent time series it is apparently younger than SUA - 153/2. Using the same tests it is fairly probable that SUA - 152 differs significantly from SUA - 153 and probable that it differs significantly from SUA - 153/2. The oldest assay of 25,380 ± 640 BP (SUA - 151) differs significantly from all the other dates.

Mr R. Gillespie of the Sydney University Radiocarbon Laboratory has informed me that sample SUA - 152 required dilution during processing which could be a possible cause of slight error though he considers that the slight variations in the dates are more likely to be due to the incomplete removal of slightly younger humic materials. Even allowing for these possibilities the assays appear to be consistent enough to permit the general conclusion that the shallow lake or marsh in which the organic sands accumulated existed between about 20,000 to 25,000 BP.

The samples taken from profile 5 for pollen analysis were processed by the technique of Mehringer (1967). The pollen was identified by comparison with modern reference material in the collection of the Botany Department, University of Tasmania. The taxonomic nomenclature follows Curtis (1956, 1963, 1967). The pollen sum used to construct the relative diagram (fig. 4) comprised all pollen counted on two slides from each sampled horizon being approximately 300 grains except between 0.52-0.53 m in which pollen was more abundant. Though the lithostratigraphy shows a distinct break between the lower three and upper two spectra the trends of the pollen curves and the sequence of radiocarbon assays indicate that sedimentation was continuous at this site and that the included aeolian sand horizons were probably deposited rapidly.

The most striking feature of the short pollen diagram is the marked decline of arboreal pollen from just over 83 to 6.2 per cent at an apparently constant relative rate and a corresponding relative increase in Cyperaceae from 2.2 to nearly 66 per cent. The increase in Cyperaceae is probably strictly local and with the low percentages of *Potamogeton* and *Myriophyllum* can be associated with the infilling of the shallow lake

to form a marsh. While part of the relative decline in the tree pollen can be directly attributed to the increase of Cyperaceae a comparison of the ratios of Gramineae and total non-arboreal pollen (excluding Cyperaceae and aquatics) to total arboreal pollen (table 2) reveals a real relative increase of grasses, herbs and shrubs, and a decrease of tree pollen with time. The trends of the curves (fig. 4) and the trends of the ratios (table 2) indicate that the vegetation of *Eucalyptus* (Myrtaceae in fig. 4) forest gradually altered to a *Eucalyptus*-savannah with herbs and occasional shrubs, in which small lakes and marshy hollows surrounded by sedges occurred.

TABLE 2

Height above OHWM in profile 5 (m)	Gramineae/AP (Myrtaceae)	Total NAP-Cyperaceae & Aquatics / AP (Myrtaceae)
0.55-0.56	3.00	3.95
0.52-0.53	1.56	2.39
0.42-0.43	0.92	1.85
0.37-0.38	0.35	0.50
0.33-0.34	0.10	0.15

It is difficult to suggest the reasons for the alteration of the vegetation from *Eucalyptus* forest to *Eucalyptus*-savannah during the period 25,000 to 20,000 BP as no deposits of comparable age are known from eastern Tasmania. Because of this it is not yet possible to ascertain whether this change was of local importance only or was a change of regional significance. The dating of the deposit is of interest as it places the vegetational change within the time of advance of the small ice cap and piedmont glacier extensions of the Tasmanian West Coast Ranges to their maximum limits which were attained after 23,640 ± 1030 BP (GaK-5597) (Colhoun 1975). The coincidence of timing suggests that the vegetation change may be a response to colder and drier climatic conditions in southeastern Tasmania as the ice sheets developed in central and western Tasmania. Evidence from further sites in eastern Tasmania is needed to test this hypothesis.

The aeolian sands which filled the hollow at Site A indicate that the land surface became unstable after about 22,000 BP. The sand dune at the southern end of Section B-C was probably also formed at this time which seems to have coincided with the phase of maximum intensity of the Last Glacial Stage between approximately 20,000 and 15,000 BP. Field evidence in eastern Tasmania indicates that many dunes and aeolian sandsheets were formed at this time (Nicolls 1958), and a ^{14}C date of 15,740 ± 700 BP (SUA - 376) has been obtained on charcoal from a sand dune 25 km north-northwest of Cremorne at Malcolms Hut Road near Richmond. The presence of finely divided charcoal fragments within the aeolian sands at Pipe Clay Lagoon indicates the occurence of fires during this time. To what extent fire may have been influential as a reinforcing agent that operated in the same direction as the colder and drier climatic effects, or directly as a causal factor in producing ground surface instability and vegetation changes is not yet possible to determine.

Once the hollow was infilled and the sands were stabilised, a deep podzol soil profile (>1m depth) was developed. The podzol exhibits deep A_1 and A_2 horizons with complete removal of free iron oxides (determined by the Sodium Dithionite-Citrate-Bicarbonate method of Jackson (1956) and colloidal jumus (fig. 5). The free iron has been eluviated as an iron-humus complex and has been concentrated in distinct B_h and $B_h(ir)$ horizons in which a maximum of 1.2 per cent free iron occurs. This value decreases rapidly to 0.3 per cent in the surface of the $B_2(ir)$ horizon, and declines to undeterminably low (< 0.1%) quantities throughout much of the horizon except for local concentration on specific beds with values of up to 0,3 per cent. The local concentration is due to groundwater effects and not directly to pedogenic illuviation.

Late Quaternary Deposits at Pipe Clay Lagoon

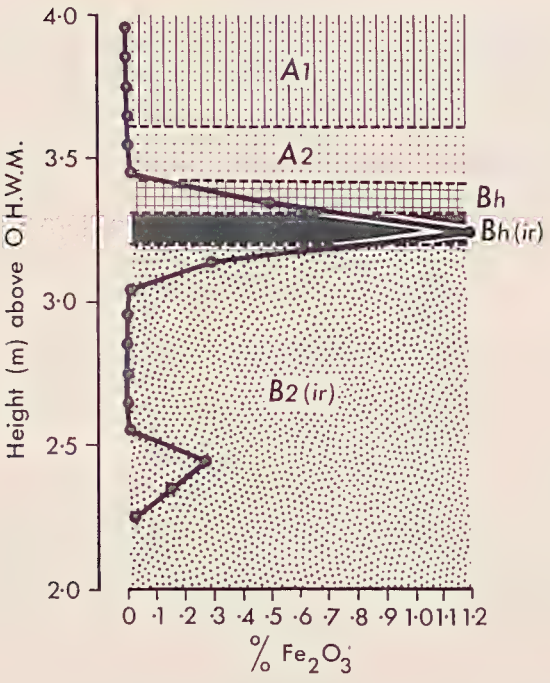

FIG. 5 - Free iron concentration in profile 4 at Site A

The marked absence of free iron in the parent sand and its concentration in the B horizons suggests that the humus-iron complex was largely derived from the vegetation cover associated with the development and maintenance of the deep podzol.

This deep podzol profile is not unique. It occurs as the regionally developed soil of sandy areas in southeastern Tasmania except for sandy marine and coastal dune deposits of Middle to Late Holocene age from which it is markedly absent. These deposits have much shallower podzol profiles (< 0.5 m depth) that have been developed during the last 5,000 to 6,000 years. The development of a deep podzol profile on the dune at Malcolms Hut Road shows that the deep podzols were formed after 15,740 BP, and are likely to have been formed by the continuous operation of processes of podzolisation on sandy substrates since about 12,000 BP. Although a full discussion cannot be included here, field evidence indicates that the widespread podzolisation of sandy regions in southeastern Tasmania during the late Glacial and Holocene periods occurred in association with a predominant *Eucalyptus* forest cover under a sub-humid climatic regime.

At sites A and B-C at Pipe Clay Lagoon thick aboriginal shell middens with charcoal and stone artifacts occur as part of the A_1 horizon and also overlie the deep podzol soil. Although not dated, the middens are probably of Middle to Late Holocene age. The thick accumulations of *Ostrea* sp. and *Mytilus* sp. shells have been partially leached of carbonate and many have powdery surfaces. The passage of carbonate through the profile is indicated by the occurrence of near neutral pH values in the B_2(ir) horizon at Site A (table 1) and of numerous soft carbonate nodules in the marine sands of Section B-C. The association of the precipitated carbonate with the middens is clearly demonstrated as the most numerous and largest nodules underlie the thickest middens. Except where influenced by midden shells or recent fertilisation

TABLE 3 Chronology of Geomorphic Events and Environmental Changes at Pipe Clay Lagoon

Stage	Approx. age BP	Geomorphic Events	Surface Stability	Climate	Soils	Probable Vegetation
Holocene	(AD 1804 - present)	Local European induced instability of sands. Coversands to 1 m depth.	Culturally induced local instability	Cool temperate sub-humid	Podzols ↑ Carbonate enrichment ↑	*Eucalyptus* woodland due to burning ↑
		Aboriginal disturbance of terrestrial sands, marine and coastal dune sands. Numerous middens formed	Stable		Podzols	*Eucalyptus* forest
	6,000					
	10,000					
	12,000					
Last Glacial	16,000	Aeolian deposits infilling hollow at Site A and forming dune near C and at Malcolms Hut Road near Richmond	Unstable	Cold-dry (?)		
	20,000					
	22,000	Organic deposits in shallow pond and marsh at Site A	Unstable ↑ becoming ↑ Stable	Cool temperate sub-humid		*Eucalyptus*-savannah becoming *Eucalyptus* forest
	25,000					
	100,000					
Last Interglacial		Marine sands, clays and beach gravels of Site A and B-C				

the pH values of the podzol A horizons are 3.5 to 4.0. The simplest interpretation is that after continuous podzolisation of the siliceous sands during the Early to Middle Holocene carbonate was introduced to the site as the middens accumulated. Subsequent leaching and precipitation of carbonate in association with seasonally fluctuating groundwater levels in the sands has increased the pH and carbonate values of some horizons in the deep podzol and some areas of the marine sands, but otherwise has not significantly altered their podzolised characteristics.

The light yellow-brown, aeolian fine sands that overlie the A_1 horizon of the podzol soil in Section B-C have resulted from the disturbance of incoherent sandy soils by European settlers. Similar thin coversands related to European forest clearance and farming developments occur widely in the settled sandy regions of eastern Tasmania and postdate AD 1804.

CONCLUSIONS

The Late Quaternary deposits exposed on the Lumeah Point peninsula provide certain limited evidence which permits an interpretation of some of the environmental processes that have operated on the landscape and changes that have occurred since the end of the Last Interglacial Stage. The conclusions from this site with some additional observations from the local region are summarised in table 3 which provides an outline chronology of the major geomorphic events and environmental changes that have occurred.

ACKNOWLEDGEMENTS

I wish to thank the University of Tasmania and the Australian Research Grants Committee for financial support towards this paper. I also thank W.R. Sigleo and M. Macphail for their valuable assistance in field and laboratory work, and G. van de Geer for drawing the figures.

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LATE QUATERNARY FAN GRAVELS AND SLOPE DEPOSITS AT ROCKY CAPE, NORTHWESTERN TASMANIA : THEIR PALAEOENVIRONMENTAL SIGNIFICANCE

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(with two tables, four text figures and two plates)

ABSTRACT

The paper describes a sequence of stratified quartzite slope deposits and alluvial fan gravels from a small catchment at Rocky Cape.

A lower series of indurated slope deposits overlain by a podzol soil profile suggests that cold climatic conditions, which favoured frost fracturing of exposed rock surfaces and gelifluction of detritus, occurred prior to the Last Glacial Stage. An upper series of unconsolidated slope deposits contains wedge structures. These deposits appear to have resulted from frost fracturing and to have been moved downslope by gelifluction processes. The wedge structures may have been produced by seasonal freezing of the ground surface during the period of maximum cold in the Last Glacial Stage (after 22,000 and before 10,000 BP).

Radiocarbon dating of charcoal and wood from organic horizons and a buried soil in the lower part of a thick sequence of alluvial fan gravels shows that they began to accumulate mainly between about 33,000 and 22,000 BP, when strong but episodic erosion of the open *Eucalyptus* forested catchment occurred. The upper part of the alluvial fan gravels does not contain organic horizons but probably accumulated after 22,000 and before 10,000 BP. The gravels were largely derived from the upper series of slope deposits which were formed in a non-forested environment.

INTRODUCTION

The Late Quaternary fan gravels and slope deposits to be described in this paper are exposed in three small quarries within the Rocky Cape National Park in northwestern Tasmania (Long. 145° 30'E; Lat. 40° 53'S) (fig. 1). The quarries occur within a 2 km catchment that faces northwestwards and has slopes of 15-30 degrees inclination. The exposures show the relationships between the slope deposits of the upper catchment and the large accumulation of fan gravels at the valley mouth.

The exposed sections reveal two distinct series of slope deposits; a lower indurated series and an upper unconsolidated series that are clearly separated by the development of a podzol soil profile on the lower series. The sections exposed in Quarry 1 reveal a series of organic-rich horizons within the lower part of the fan gravels, which also contain charcoal and wood fragments. One of the organic horizons forms part of an undisturbed palaeosol with roots in growth position. No organic-rich horizons, wood fragments or palaeosols were observed in the upper part of the sequence of fan gravels, but some finely divided charcoal occurs near the surface of the deposits. The fan gravels and slope deposits are overlain by deposits of peaty sand.

Study of the morphology and stratigraphy of these landforms and deposits, analysis of the pollen contained in the organic horizons, and ^{14}C dating gives some glimpses of the changing geomorphological processes and palaeoenvironmental conditions that affected this locality during the Late Quaternary. Unfortunately the evidence from this site is fragmentary and the time record is discontinuous. The significance of the

data can only be evaluated in conjunction with geomorphological and palaeoenvironmental evidence which is becoming available for other locations in Tasmania (Colhoun 1975a, 1976, 1977a, 1977b, 1977c). This paper, therefore, presents the local evidence from Rocky Cape and suggests an interpretation of the geomorphological and palaeoenvironmental changes that have probably occurred.

MORPHOLOGY, STRATIGRAPHY AND SEDIMENTS

The Rocky Cape peninsula is composed of unmetamorphosed quartzites of Precambrian age which occur on the axis of the northeast trending Rocky Cape Geanticline (Banks 1965). The peninsula is characterised by a ridge of hills of similar trend which vary between 250 m and 300 m in height. The ridge is dissected into numerous small river basins with steep slopes on the middle and lower parts of which deposits of angular quartzite fragments have accumulated. Small tors occur on and near the summits of the main ridge and minor interfluves.

The slopes of the river basin vary from about 15 to 30 degrees.. The upper slopes have straight profiles developed on rock. The middle and lower slopes are mantled with quartzite detritus and decline towards the axis of the stream and the apex of the alluvial fan (fig. 1). The slope deposits grade into alluvial fan gravels, the surface of which slopes seawards at 5 to 10 degrees.

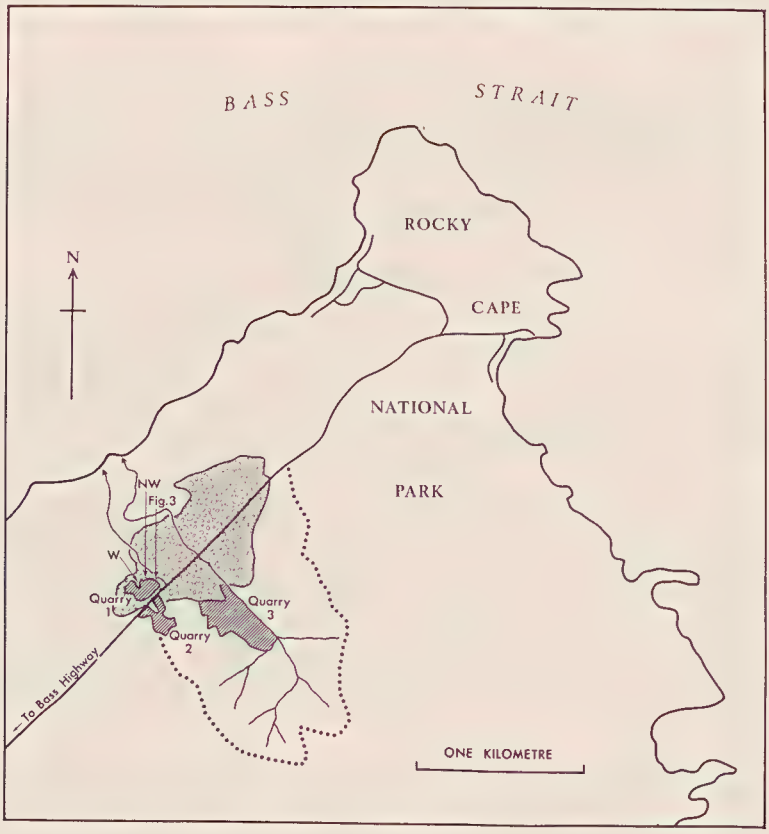

FIG. 1 - Location of Rocky Cape Catchment

The surface of the fan declines from 110 m to 28 m. The periphery slopes at 14 degrees to a rock terrace that is thinly mantled with gravel on its upper part and consists of jagged outcrops of quartzite on its seaward side. The rock terrace, which continues for a short distance beneath the fan gravels, is probably a surface of marine abrasion developed during part of the Last Interglacial. Holocene dune sands occur between HWMST and 4 m (fig. 2).

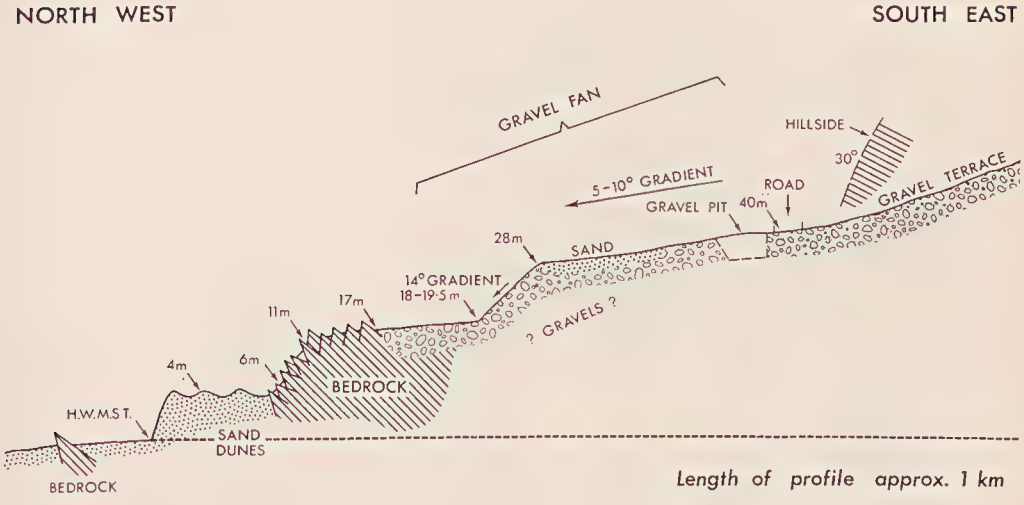

FIG. 2 - Profile from the valley to West Bay across the alluvial fan (surveyed by Stephens and van de Geer)

The stratigraphy of the deposits exposed in the quarries at Rocky Cape is summarised in table 1.

Several aspects of the sediments that form the slope deposits and fan gravels require further discussion.

The surface 0.5 - 0.75 m of peaty sand is widespread on the lower slopes and surfaces of the area. It has probably been formed during the Late Holocene by the acolian transport of fine sand from the dunes and beaches of West Bay onto the surface of the heath vegetation which facilitated its accumulation.

The upper series of slope deposits exposed in quarries 2 and 3 consists of sharp-edged quartzite fragments that have been derived from the subjacent bedrock. The shape of the 20-150 mm fracture fragments is largely determined by the fractured nature of the bedrock but the form and structure of the deposits is identical with congelifractate deposits of periglacial origin. Where the upper quartzite slope deposits have overlain the indurated surface of the lower quartzite slope deposits or the quartzite bedrock prior to quarrying, the surface of contact has been locally striated and shaven off by the downslope movement of the materials. Locally the downslope movements have produced small drag-folds in the underlying quartzite.

Between 0.5 and 1.0 m from the surface of these deposits five wedge-shaped

TABLE 1

LATE QUATERNARY DEPOSITS AT ROCKY CAPE

Age	Pollen samples	Quarry 1	Pollen samples	Quarry 2	Quarry 3
Holocene		about 0.5 m peaty sand	H 0-0.1 m H 0.35-0.4 m H 0.7-0.75 m	0.75 m peaty sand	about 0.5 m peaty sand
Last Glacial		1 m fine quartz sand with sparse fragments of charcoal, 11-12 m of bedded quartzite gravels with sand lenses. In the lower part of these deposits lenses containing charcoal, wood fragments and a thin palaeosol horizon occur. The most important horizons in descending order are:		1-5 m of angular quartzite debris; clasts 20-150 mm size; downslope pseudostratification inclined at 10-15 degrees; chemically unweathered.	1-4 m of angular quartzite debris; clasts 20-150 mm size; downslope pseudo-stratification inclined at 10-15 degrees; chemically unweathered; contains wedge structures of 1-3 m depth and 0.5-1.0 m width.
26,760±1360 BP (GaK-5153)	G	1.5 m from the base of the east wall an horizon of charcoal and wood fragments			
[28,930 $^{+1970}_{-1580}$ BP (GaK-5154)] *	F	0.7-2.25 m from base of north-west wall an humic enriched horizon 1.4-1.55 m thick occurs which contains sparse charcoal and is cemented with manganese			
33,240 $^{+5610}_{-3270}$ BP (GaK-5691)	E	4.5-4.85 m from the base of the north wall (fig. 3) an organic sand lens with charcoal			

24,090±1030 BP (GaK-5155)	D	2.3-2.78 m from the base of the north wall a fossil soil with roots in growth position occurs in association with charcoal and charred wood			
	C	1.5-1.6 m from the base of the north wall an organic sand lens with sparse charcoal			
$32,350^{+3680}_{-2510}$ BP (GaK-5690)	B	1.1-1.2 m from the base of the north wall an organic sand lens with charcoal			
	A	0-0.25 m from base of north wall an organic sand horizon with sparse charcoal The base of the fan gravels is not exposed			
Pre-Last Glacial (?)				Podzol soil profile 0.5 m thick occurs on 0.5 to 1.0 m of strongly indurated angular and chemically unweathered quartzite debris; clasts 20-150 mm size with a downslope pseudostratification of 10-15 degrees inclination.	

*From an adjacent part of the west wall of Quarry 1

structures occur 5-10 m apart and vary from 1-3 m in depth and from 0.5-1.0 in width (plate 1). The quartzite fragments within the wedge structures have had their long axes reoriented so that they are parallel with the margins of the wedges and almost at right angles to the long axes of the fragments in the slope deposits. In 1965 N. Stephens (pers. comm). recorded a similar wedge structure in the alluvial fan gravels of Quarry 1. The wedge began beneath the surface metre of fine sands and penetrated the underlying gravels to 1.5 m depth.

PLATE 1 - Wedge structure in the quartzite slope deposits at Quarry 3 at Rocky Cape

While the wedge structures resemble ice wedge pseudomorph forms in many respects and definitely occur intraformationally within the fractured quartzite slope deposits, their location on a slope of 10-15 degrees inclination and the absence of any records of ice wedge pseudomorphs from much more likely sites in Tasmania makes such an explanation unlikely. The way in which the quartzite fragments are arranged within the wedge structure as a secondary fabric approximately at right angles to the fabric of the slope deposits indicates that some force has selectively disturbed the particles in the wedges after they were primarily deposited. The wedges do not appear to have resulted from collapse or transport of particles into tension cracks produced by desiccation of the ground surface or simply to pressures induced by wetting and drying of the ground as can occur in areas of expandable materials (Black 1976). The non-expandable nature of the coarse quartzite detritus and the reorientation of the particles without any addition of extraneous materials of different form or texture, as would be expected if a void space were infilled, suggests that the only forces involved operated within the surface layers of the ground without the development of an open crack. It is possible that occasional severe seasonal freezing and subsequent thawing of moisture in the ground surface under colder and more continental climatic conditions could have produced the pressures that formed these wedge structures.

The alluvial fan gravels exposed in Quarry 1 have been derived mainly from the upper series of slope deposits (fig. 3). They consist of bedded poorly to moderately sorted deposits of medium to coarse cobbles of 50-200 mm size with a medium to coarse sandy matrix that varies from 50 to 70 per cent of the deposit (plate 2). The beds dip radially outwards from the apex of the fan at angles of 5-10 degrees inclination, and increasing amounts of sand and silt occur on the periphery of the fan.

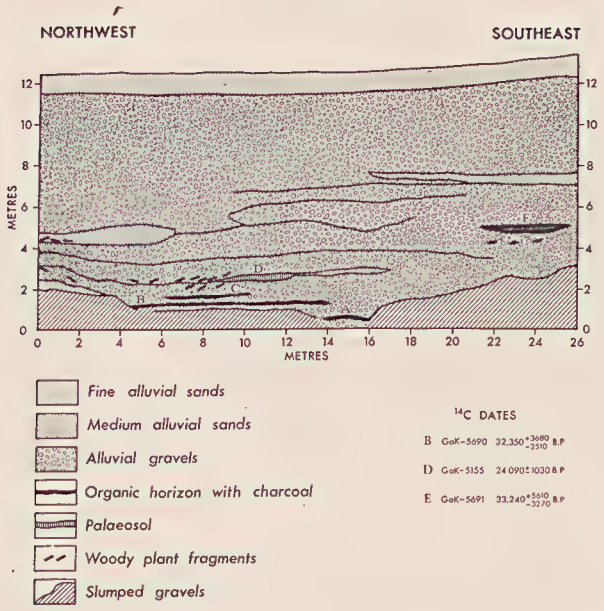

FIG. 3 - Alluvial gravels in northern wall of Quarry 1

PLATE 2 - Quartzite alluvial fan gravels in Quarry 1 at Rocky Cape showing the fossil soil horizon

The deposits vary between a light grey (7.5YR 8/1) and brownish-grey (10YR 4/1) colour, but are locally dull orange (7.5YR 6/4) or brownish-black (7.5YR 2/2) in colour where stained with iron and humic or manganese materials respectively (Standard Soil Color Charts 1967).

The wood and most of the charcoal fragments within the fan gravels occur in the lower five metres. Some of the wood fragments have been abraded through transport by floodwaters which eroded the slope deposits from the middle part of the valley and deposited them in the fan gravels at the valley mouth. Most of the lenses that contain significant amounts of charcoal and the humic horizons do not represent ground surface accumulations but have resulted from the redeposition of wood, charcoal and humic materials derived by erosion of a formerly stable land surface(s) or temporarily stable surfaces in the catchment. The partially burnt character of much of the wood and the abundance of charcoal suggests that the initial erosion of the catchment which produced the materials may have occurred after heavy and frequent firing of the catchment. Much of the humic staining in the alluvial gravels is due to later solution and precipitation of colloidal organic matter in humus-iron complexes by groundwater percolation. Only the 0.25-0.4 m thick and 3.6 m long exposure of organic sandy-silt palaeosol as horizon D certainly represents the development of a surface of temporary stability. The *in situ* roots and sharp upper boundary of the soil clearly indicate a significant break in the deposition of the fan gravels at this point. However, an hiatus in accumulation need not necessarily have occurred over the entire surface of the fan at this time.

In Quarry 2 a podzol soil profile has been developed on the surface of the lower slope deposits and beneath the upper slope deposits. The podzolised surface probably passes under the fan gravels and although it is not a deeply developed profile it nevertheless seems to represent a significant break in time between the deposition of the lower and upper series of slope deposits. The fact that the profile is developed on the surface beds of the lower indurated slope deposits and not within the base of the upper slope deposits indicates that it is not merely an horizon which has been enriched with humus-iron compounds precipitated from groundwater perched on the compacted surface, but represents the remnant of a ground surface which was exposed to processes of podzolisation after the deposition and induration of the lower slope deposits had been completed.

The lower series of slope deposits although thinner has identical characteristics with the deposits of the upper series except for the high degree of induration and the absence of wedge structures. The deposit appears to be a congelifractate derived from the quartzite during an earlier phase of landscape instability induced by cold climatic conditions. Partial erosion of the surface of the lower slope deposits indicates that they, like the quartzite of the upper slopes, contributed to the formation of the upper slope deposits and indirectly to the alluvial fan gravels.

DATING

Dating of the sequence of organic horizons in the lower part of the fan gravels has proved problematical. Some of the dates have large standard errors and the assay from horizon D appears at first sight to be younger than the assays from the overlying horizons E and G. An additional assay has been obtained for wood deposited 0.5 m above the floor of Quarry 1 on its seaward or western wall. The assay was $28{,}930 \pm \frac{1970}{1580}$ BP (GaK-5154) and the bed that contained the wood occurred at approximately the same level as horizon F in the northwest wall. However, owing to rapid lateral and vertical variations in the fan gravel deposits precise correlation could not be obtained.

If the probability limits of the time ranges of the assays are examined then at 1σ there is no overlap of GaK-5155, at 2σ there is time overlap with assays 5153 and 5154, and at 3σ with all the assays. If, however, the data is tested using the

relationship of the arithmetic difference between the assays and the square root of the sum of the squares of each standard deviation, as recommended by Polach and Golson (1966), it is found that all the arithmetic differences are 1 and 2 times the latter values. Both techniques indicate that the value of 24,090 ± 1030 BP (GaK-5155) for the palaeosol cannot be considered as significantly different from the other assays obtained on wood and charcoal from the lower part of the fan gravels. As this assay has the lowest standard deviation values of the assays and is associated with a stable ground surface, it is probably the most accurate of the determinations. Also, since the assays below and above this level were made on detrital wood and charcoal fragments derived by erosion of the ground surface(s) in the catchment the age of the wood and charcoal fragments on any horizon may predate the age of its deposition but are unlikely to postdate it.

The ^{14}C assays at Rocky Cape, therefore, may be interpreted as indicating that between approximately 44,000 and 22,000 BP (2σ limits) erosion of the catchment destroyed a former stable land surface. Later and areally restricted stable surfaces of short duration as demonstrated by the palaeosol of horizon D were also destroyed by erosion while the lower part of the fan gravels accumulated. Due to the large σ values of the older assays it is likely that these events occurred mainly during the latter half of the time range between about 33,000 and 22,000 BP rather than during the earlier part.

The absence of wood and charcoal fragments in the upper part of the alluvial fan gravels suggests that the early period of intermittent severe erosion from the catchment with deposition on the fan surface was succeeded by a more intense phase of erosion and deposition, when the upper series of slope deposits were highly mobile and the fan surface was not even temporarily stabilised by shrub or tree vegetation likely to yield wood or charcoal fragments to the accumulating fan deposits. The appearance of small finely divided particles of charcoal in the surface metre of fine sands may reflect a return to slightly more stable ground surface conditions at the end of the Last Glacial. This charcoal may possibly relate to firing of the catchment by early aboriginals in the Rocky Cape area (Jones 1968) but it could be of natural origin. Unfortunately not enough charcoal could be obtained for dating.

POLLEN ANALYSIS

Samples A-G were collected from the organic horizons in the fan gravels and samples H 0.1 m, H 0.35-0.4 m and H 0.7-0.75 m were taken from the overlying Holocene peaty sand deposits. In addition pollen trap samples were collected from the middle part of the catchment southeast of Quarry 3 to assess the modern pollen rain. The samples were processed by the Faegri and Iversen technique (1964) and relative counts based on sums of 300 grains of all pollen including the spores of *Dicksonia* and *Cyathea* were made. The pollen types were identified by comparison with reference slides of modern pollen in the collections of the Geography and Botany Departments of the University of Tasmania. The taxonomic nomenclature follows Curtis (1956, 1963, 1967). The percentages are given in table 2.

Because of the problems associated with transported organic materials that contain pollen and the pollen content of fossil soils (Grichuk 1967; Riezebos and Slotboom 1974; Dimbleby 1957, 1961a, 1961b; Havinga 1974) only limited results were expected. However, it was hoped that some indications of how the groups of plants composing the vegetation varied during the period when the lower part of the fan gravels was deposited might be obtained. It was also hoped that some general indications of how the Holocene vegetation changed at Rocky Cape could be determined. The most important pollen groups have been represented according to stratigraphic position in figure 4. Although it is recognised that any horizon may contain derived pollen, it is probable that most of the tree and shrub pollen on each horizon was transported from the catchment with the wood and charcoal fragments and deposited at approximately the same time.

TABLE 2

POLLEN PERCENTAGES FROM ROCKY CAPE

Vegetation	Pollen group	Last Glacial fan deposits							Holocene peaty sand			Pollen trap		
		A	B	C	D	E	F	G	H 0.7-0.75 m	H 0.35-0.4 m	H 0-0.1 m	Aug. 1974 Jan. 1975	Jan. 1975 Sept. 1975	
SUBALPINE	*Pherosphaera hookeriana*	1.0	3.5	+	1.2			5.1		1.8				
	Dacrydium franklinii	+	+	+		+						1.2		
TEMPERATE	*Eucryphia* sp.												+	
RAIN	*Nothofagus cunninghamii*	+		+			+		8.9	15.4	5.2	+		
FOREST	*Phyllocladus aspleniifolius*	8.8	3.5	3.4	+	+	+	?	2.2	1.8	1.0	+		
	Acacia								?	+	?	+	2.6	
	Amperea xiphoclada								+		2.3			
	Banksia marginata	+		+	1.5		1.3			+	+		1.7	
	Bauera rubioides		?	+			+						+	
	Casuarina	4.0	4.1	16.5	17.4	25.9	23.1	74.3	1.4	1.8	1.3	5.1	+	
	Conifers, introduced					+	+			+	+	1.5		
	Dilleniaceae													
	Epacridaceae	4.5	5.5	2.7	2.1	+	1.6	+	7.3	8.3	31.8	59.6	27.3	excl. *Monotoca*
	Monotoca	+	+	3.7	31.7	5.3	3.8	5.4	7.3	1.2	?			
TREES	*Eucalyptus*	30.3	29.3	29.6	9.3	29.4	30.3	1.8	38.8	32.9	23.4	2.4	+	
AND	*Leptospermum*	2.8	2.3	1.5	5.1	1.6	1.3		3.2	3.1	2.9	3.0	24.2	incl. some
SHRUBS	*Melaleuca*	1.8	3.2	1.2	+	3.0	10.0		5.1	1.8	2.3	+	1.7	*Baeckea?*
	Myrtaceae, others	+	+	+	1.5	+						+	+	
	Papilionatae	2.5	3.2	1.2	+	19.9	15.0	2.4	6.5		2.9	1.8	32.8	
	Proteaceae	+	+	2.7	+		+	2.1		+			+	
	Hakea microcarpa											+		
	Rhamnaceae	+	+			?	1.3	+				+	+	
	Rubiaceae											+	2.3?	
	Coprosma	+	+											
	Rutaceae	+			+					+	+			
	Santalaceae									+				
	Tremandraceae				+									

HERBS	Caryophyllaceae		+			+					+			
	Chenopodiaceae										+		+	
	Compositae	14.8	15.1	11.0	5.7	+	+	2.1	+	1.2	3.9	+		incl. shrubs
	Cruciferae				+					+	+			
	Cyperaceae	3.5	2.6	2.1	2.1	1.0	+	+	2.2	4.0	2.3	1.7	+	incl.
	Gramineae	16.0	16.2	17.1	+	1.8	2.8	2.1	+	2.1	3.2	7.8		*Gymnoschoenus*
	Haloragaceae	2.8	3.2	+	13.8				+	+	+			*sphaerocephalus*
	Iridaceae		?		·							+		
	Liliaceae												+	*Xanthorrhoea*
	Onagraceae			+		+		?		+		+		*australis*
	Plantaginaceae										+	+		
	Polygonaceae		+									+		
	Ranunculaceae											+		
	Restionaceae	+	+		+			2.4	3.0	13.8	9.7	3.3		
	Umbelliferae	1.8	+	+										
	Urticaceae											+		
TREEFERNS	*Cyathea* sp.		+		+									
	Dicksonia antarctica				+		+		+					
	Unknowns													
	Total	399	345	328	334	432	320	331	369	325	308	332	348	

+ < 1%

It is unfortunate that the ^{14}C dates do not indicate more precisely when each horizon was deposited.

FIG. 4 - Stratigraphic trends of some pollen groups (Pollen trap values are the mean of two samples, table 2)

The present vegetation of the Rocky Cape peninsula is a heath association but it varies from patches of *Eucalyptus* woodland through lowland scrub and heath to local areas of herbland (Jackson, in Specht *et al.* 1974). In the catchment the vegetation varies from grassy-sedge-heath with *Gymnoschoenus sphaerocephalus*, Restionaceae, *Xanthorrhoea australis*, Gramineae and epacridaceous species to open-scrub-heath dominated by *Sprengelia incarnata* with *Leucopogon*, *Banksia marginata*, *Leptospermum*, Papilionatae, *Casuarina*, *Acacia*, and occasional *Eucalyptus* saplings. This vegetation is reflected in the modern pollen rain.

The graph showing the stratigraphic trends of some of the pollen groups (fig. 4) indicates a marked decline of *Eucalyptus* pollen and a marked increase in pollen of Epacridaceae, especially *Leucopogon* and *Sprengelia incarnata*, in horizons H 0.7-0.75, H 0.35-0.4 and H 0-0.1 of the Holocene peaty sand. The changes indicate reduction in the extent of *Eucalyptus* forest and its replacement by open-scrub and heath. This change is probably the result of aboriginal firing of the area during the Middle and Late Holocene.

The Temperate Rain Forest component (table 2) of all horizons is considered to result from long distance transport of pollen to the site, but the relatively high percentages of *Nothofagus cunninghamii* in the peaty sand suggest a more proximal source to the south during the Holocene than during the Last Glacial.

The most important components of the glacial age horizons A-C are *Eucalyptus* spp. (about 30%), Gramineae (16-17%) and Compositae (11-15%), with significant quantities of *Casuarina* and Epacridaceae. These groups suggest that the vegetation was an open *Eucalyptus* forest (Specht 1970). In the fossil soil of horizon D *Eucalyptus* is relatively decreased by the high value (31.7%) for *Monotoca*, but *Casuarina* maintains its relative increase. *Eucalyptus* maintains about 30 per cent on horizons E and F but markedly decreases to 1.8 per cent on horizon G. This decrease is partly due to the strong increase in *Casuarina* but may also be a real decrease related to increased

conditions of surface instability in the catchment and on the fan.

Between horizons C and G *Casuarina* expands from 16.5 to 74.3 per cent and above horizon G Gramineae and Compositae decrease to less than 3 and 6 per cent respectively. The sequential changes suggest that the understory of the open *Eucalyptus* forest gradually altered from a predominantly grass and herbaceous cover to a heath-shrub understory of *Casuarina*, Epacridaceae and Papilionatae.

CONCLUSIONS ON ORIGIN AND PALAEOENVIRONMENTAL SIGNIFICANCE

The lower series of quartzite slope deposits in Quarry 2 are the oldest surficial deposits exposed at Rocky Cape. Although the angular form of the fragments comprising these deposits may be partly predetermined by initial structures in the quartzite, the angular shapes of the chemically unweathered fracture fragments, the downslope stratified structure, and the highly compacted nature of the deposit, which is not cemented by iron and manganese that could have formed rapidly in the acid soil water environment, suggests that the deposit was largely formed by frost shattering of exposed rock slopes at a time which considerably preceded the formation of the fan gravels and upper slope deposits. While it is possible that such deposits could have been formed by strong frost action at the time of maximum glaciation in the Forth, Mersey and Leven valleys of northwestern Tasmania there is no way of directly correlating the slope deposits with the Forth Glaciation (Colhoun 1976). Their geographic location, stratigraphic position, and separation from the upper series of slope deposits by the development of a weak podzol soil profile on their surface would, however, support the interpretation that they were formed during cold climatic conditions which preceded the Last Glacial Stage.

The alluvial fan gravels exposed in Quarry 1 at the mouth of the catchment probably began to accumulate about or slightly after 33,000 BP and continued to accumulate throughout the Last Glacial Stage. The occurrence of charcoal and organic rich horizons demonstrate both stripping of the soil and surface organic debris from the catchment and its deposition within the lower part of the fan gravels. This erosion was probably subsequent to frequent heavy firing of the catchment. The thin humic palaeosol indicates a temporary period or local surface of stability on the fan. Pollen analysis of the organic deposits indicates that open *Eucalyptus* forest with a grass-shrub understory occupied the area while the lower part of the fan gravels accumulated.

The upper part of the alluvial fan gravels (above horizon E, fig. 3) in Quarry 1 mainly accumulated after about 22,000 BP and before 10,000 BP when strong erosion of unstable slope detritus from the catchment supplied the material for deposition on the fan surface. The absence of organic or buried soil horizons from the unconsolidated but presently stable, upper series of slope deposits in quarries 2 and 3 suggests that these deposits should be correlated with the upper organically sterile sequence of fan deposits. The development of intraformational wedge structures between one and three metres of the surface in both formations supports this correlation. The fossil wedge structures have been developed as a result of ground surface pressures that may have been caused by seasonal deep freezing of the ground surface. The angular shapes of the chemically unweathered fracture fragments and the downslope stratified structure strongly supports the interpretation that they were formed under much colder climatic conditions than at present, during which strong winter frosts would physically fracture the exposed quartzite rock and would facilitate the downslope transport of the debris by gelifluction processes.

Although there is no direct palaeobotanical evidence to indicate the nature of the vegetation in the catchment while these deposits were being formed the nature and quantity of the slope deposits indicates that the catchment could not have been forested, and was probably an open environment in which grasses, herbs and low shrubs formed the bulk of the vegetation.

Late Quaternary Deposits, Rocky Cape, Northwestern Tasmania

The field evidence from Rocky Cape indicates that the alluvial fan gravels and the upper series of slope deposits were mainly formed during the period of maximum cold in the Last Glacial Stage when the glaciers of western and central Tasmania were at their maximum extent (about 18,000 BP), when preexisting soil and regolith were mobilised, when freshly derived fragmental slope deposits were formed and moved downslope on many steep slopes in northwestern Tasmania (Colhoun 1976a), and when open non-forested environments were probably much more widespread on low ground than at present (Macphail 1975; Colhoun 1977a).

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THE REMARKABLE CAVE, SOUTHEASTERN TASMANIA : ITS GEOMORPHOLOGICAL DEVELOPMENT AND ENVIRONMENTAL HISTORY

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(with one table, two text-figures and three plates)

ABSTRACT

The paper describes a sequence of slope and valley-fill deposits that occur in a fossil geo at Remarkable Cave on the Tasman Peninsula of southeastern Tasmania. These deposits overlie a cobble beach deposit on the floor of the geo which is believed to be of Last Interglacial age. The slope and valley-fill deposits predate 37,000 BP and an early Last Glacial age is suggested. Pollen from organic and charcoal-rich horizons suggest that the vegetation of the area was mainly a *Leptospermum* scrub or heath with local areas of *Eucalyptus* forest/woodland. *Pomaderris apetala* and *Dicksonia antarctica* occurred in damp valleys. Fire was an important environmental factor during this time and probably contributed to the maintenance of sub-climax vegetation associations and permitted severe episodic erosion of soil and regolith materials from the steep valley sides after burning. The sea cave known as Remarkable Cave was mainly formed during the last 6,000 years and is much younger than the geo which it intersects.

INTRODUCTION

The Remarkable Cave is a large, elongated, vertical-sided sea cave of the blowhole type situated 5 km south of Port Arthur on the Tasman Peninsula (fig. 1). The cave attracts tourists because it is possible to descend to a small cobble beach, where the cave intersects a fossil geo that is plugged by a fill of Late Quaternary sediments, and to look seaward through the cave. The distant light outlines the cave entrance which has a shape similar to the map of Tasmania (plate 1.)

On first visiting the Remarkable Cave I was impressed by three things. First, the exploitation by wave erosion of a fault structure which has produced the Remarkable Cave at a time much later than the wave erosion that created the geo which it intersects. Second, the presence of a buried beach deposit in the bottom of the geo. This beach is seen on the left at the base of the steps that descend to the modern cobble beach (plate 2). Third, the presence in the geo of a thick plug of slope and valley-fill deposits that overlies the boulder beach and has not been completely re-excavated by waves moving directly up the geo from the open sea (plate 3). Inspection of these deposits revealed that they contained wood, plant remains, charcoal and pollen in numerous horizons. The possibility of dating slope and water laid deposits in association with marine deposits and erosional forms prompted further investigation of these deposits in the hope that the results would throw some light on the Late Quaternary environmental development of this locality. This paper will present a description of the landforms and deposits and will discuss some aspects of the Late Quaternary development of the Remarkable Cave area.

LANDFORMS AND GEOLOGY

The Remarkable Cave is developed along a nearly vertical fault plane which dips at 80°NE, trends towards 165° and is downthrown to the southwest by about 2 m. The fault occurs in the contact zone between Triassic sandstones and a sill-like intrusion of Jurassic dolerite (Powell 1967). Much of the zone consists of deformed hornfels

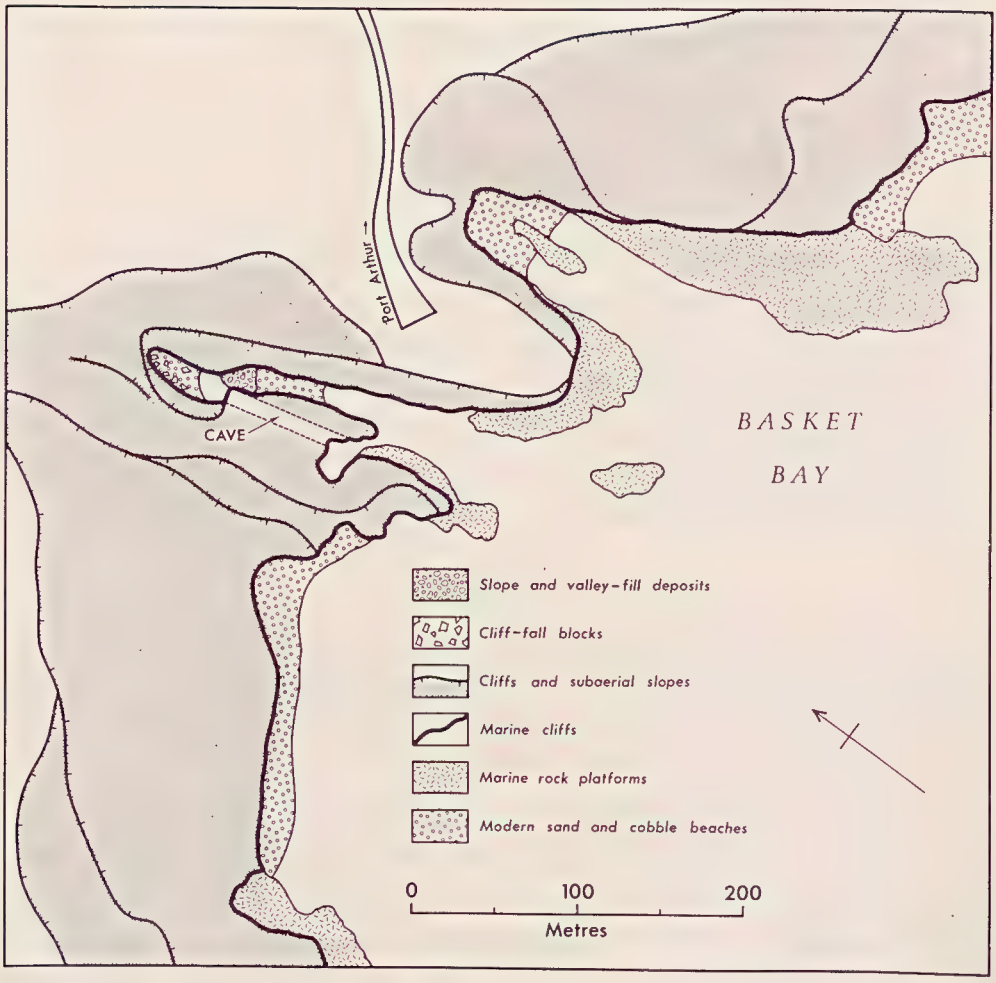

FIG. 1 - Location of the Remarkable Cave

developed between the sandstones that occur southwest of the fault and the dolerite which occurs below the floor of the cave and in the lower walls of the geo to the east.

The geo trends at about 165°, exceeds 25 m in depth and was developed along a line of structural weakness that intersects the Remarkable Cave fault at the back of the cave. The southwestern wall of the geo is inclined at 82° and the northeastern wall at 67°.

PLATE 1 - The Remarkable Cave: a sea cave developed along a fault plane during the Holocene

PLATE 3 - The slope deposits that fill the fossil geo at Remarkable Cave

PLATE 2 - Cobble and boulder beach of Last Interglacial age sealed in the fossil geo at Remarkable Cave

The Remarkable Cave, Southeastern Tasmania

At and south of the mouth of the geo and the entrance to Remarkable Cave the 100-150 m high cliffs of Basket Bay exhibit a two-storied profile. The upper and areally more extensive part of the profile consists of a slope of 20-30° inclination which has been sub-aerially sculptured. Several small, shallow, first order valleys have been eroded into this slope and are truncated by the lower near vertical cliffs of marine erosion. Some of the cliffs have marine eroded platforms at their base.

The upper slopes on the sides and at the head of the geo are of subaerial origin and represent the truncated remnant of an old, small first order valley. The lower sides of the geo and of the Remarkable Cave were both formed by wave erosion along lines of structural weakness at different times. In the geo, however, the erosion coincided with the axis of a small valley whereas the Remarkable Cave was formed as a direct result of erosion along a fault plane with sequential sea cave and blowhole stages prior to the present development of a small cobble beach where it intersects the geo. The floor of the geo is partly plugged with cobble beach deposits that underlie a thick succession of slope and valley-fill deposits.

STRATIGRAPHY OF DEPOSITS IN THE GEO

Over 17 m of unconsolidated beach, slope and valley-fill deposits occupy the inner part of the geo and separate it from the small cobble beach at the head of Remarkable Cave (fig. 2). The seaward section shows the relationship of these deposits with the underlying boulder and cobble beach in the bottom of the geo.

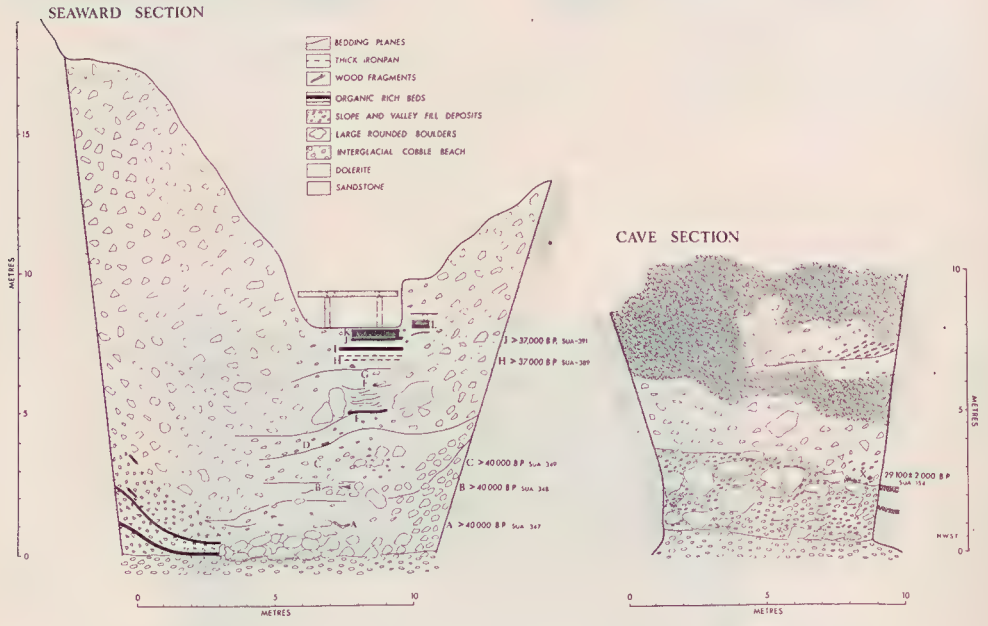

FIG. 2 - Sections of deposits exposed in the geo

Seaward Section

The lower 2-4 m of the southwestern side of the seaward section shows a sequence of stratified slope deposits composed mainly of angular fragments of sandstone from the upper wall and slope above the geo with some hornfels fragments (fig. 2). The rock fragments vary between 20 and 150 mm with some larger fragments exceeding 200 mm in diameter. The rock fragments constitute from 15-35 per cent of the deposit and are set in a matrix of medium to fine sand. The beds are inclined at 10-40° NE, the dip becoming less as the slope deposits merge with the contemporary valley-fill deposits in the axis of the geo. Near the wall of the geo the rock fragments have a strong downslope orientation of 35-40°NE. The hornfels fragments are sharp-edged and platy. From 10-40 per cent of the sandstones exhibit sharp edges and the remainder have weathered surfaces and are slightly rounded on the edges. The deposits vary from dull yellowish-brown (10YR 5/3) and dull yellow orange (10YR 6/4) to greyish-brown (7.5YR 4/2) and dark brown (7.5YR 3/3) (Standard Soil Color Charts, 1967). Locally the deposit is strongly mottled with bright brown (7.5YR 5/8) and bright reddish-brown (5YR 5/8) iron mottles, and contains thin ironpan layers and manganese nodules up to 20-30 mm size. The boundaries between the strata merge except at the base of the organic rich horizons which have sharp boundaries with the underlying beds and more gradual boundaries with the overlying beds.

The deposits contain sparse charcoal fragments between 0-100 mm, are rich in organic detritus which includes wood and charcoal fragments between 1 and 1.1 m, and in humic materials with charcoal between 2.20 and 2.25 m. Traces of charcoal also occur in the overlying beds at 2.10-2.30 m and at 3.30-3.50 m. The organic and charcoal rich horizons in the lower part of this deposit represent several stages of transport of surface organic litter and soil materials from the slope above while the rock fragment-rich beds were formed by erosion of the valley slope and upper wall of the geo.

Between 4 and 17 m the slope deposits consist of angular, slightly weathered blocks of sandstone with occasional hornfels set in a fine sandy matrix which gives the deposit a dull yellow orange (10YR 7/2) colour. The blocks are mainly of 0.05-0.3 m size with occasional boulders up to 1 m in diameter. These deposits do not contain organic materials or detrital charcoal, are poorly bedded and sorted, and have a downslope fabric. One weakly developed but extensive bedding plane occurs between 6 and 7.5 m height.

At the foot of the northeastern wall of the geo the sandstone slope deposits are coarser than those adjacent to the southwestern wall and are slightly richer in hornfels fragments. They vary from 0.02-0.3 m in size, are angular to subangular in form, are coarsely bedded, poorly sorted, have a downslope fabric, and do not contain either organic detritals or charcoal. Above 5.5 m the amount of hornfels in the slope deposits becomes very small and at the top of the section the sandstones in the surface 0.5-1.0 m are strongly weathered. The lower part of these deposits has partly been produced by erosion of the upper part of the geo wall but most of the deposits have been produced by erosion of the sandstone slope above the geo wall.

The axis of the geo is filled with a succession of stratified minerogenic and organic-rich deposits which merge laterally on either side into the slope deposits. The basal metre consists of subrounded weathered sandstone, hornfels and dolerite boulders of 0.5-1.0 m diameter which overlie buried cobble beach deposits on the floor of the geo. The fossil cobble beach deposits are only exposed when the overlying modern beach cobbles are temporarily removed after storms but they were observed to be set in a matrix of coarse sand and are weakly cemented with iron which occassionally occurs at 5 mm thick pans. The overlying large blocks represent cliff fall boulders which have been partially rounded by former wave action. The sandstones have also been weathered during burial beneath the valley fill-deposits.

The detailed stratigraphy of the valley-fill deposits is complex. Only the main characteristics of the deposits that elucidate their origin will be described here. Between the rounded boulders and the handrail the deposits consist mainly of brownish-grey (7.5YR 4/1) to greyish-brown (7.5YR 5/2) fine sandy slope deposits which contain 10-15 per cent of sandstone and hornfels fragments of 10-300 mm and occasional large blocks of over 1 m in diameter. Many of the sandstone pebbles are strongly weathered and the deposits contain yellowish-brown (10YR 5/6) and orange (5YR 7/6) coloured iron mottles and ironpans up to 10 mm thick. Some horizons of the sandy deposits are laminated and indicate that some of the fill was occasionally transported a short distance along the axis of the valley and was deposited by water in the accumulating sedimentary fill.

The deposits contain charcoal, detrital organic materials including leaf and twig fragments, and branches up to 1 m long and 0.1 m in diameter. The branches have deformed cross sections due to burial beneath the sedimentary load. Most of the organic material in the lower part of the section was derived by erosion of surface litter, soil, and the transport of wood fragments towards the axis of the valley from the slopes above the geo. Beside B (fig. 2) water deposited laminae of fine sand interfinger with five horizons of transported organic materials. Between E and F eight organic rich horizons alternate with the stratified sandy slope and washed deposits. The large 1 m sandstone boulder depresses the margins of the first and second organic horizons but the margins of the fourth to eighth horizons curve upwards over the boulder,which was deposited between the time of accumulation of the second and fourth horizon. Above 6.45 m, the bedding plane above G, the deposits are slightly less consolidated than below 6.45 m, the cross sections of wood fragments are little deformed, charcoal and humus is more abundant than wood, and the organic horizons are more fibrous and matted. Above J the organic horizons are penetrated by modern roots. The horizontality of these upper organic horizons and the fibrous nature of several suggest that they may have been developed *in situ* on the damp floor of the valley at the same time as sandstone fragments, sand, charcoal and wood fragments were transported to the valley floor from the valley sides. Similar organic horizons penetrated by modern roots at L have been buried by the sandstone slope deposits.

Cave Section

In the northeastern corner of the cave by the steps the section reveals 2-3 m of beach cobbles set in a medium to coarse sandy matrix. The cobbles are 0.2-0.25 m in diameter, are subrounded to subangular in form and elongated and flattened in shape. They are accompanied by cliff-fall boulders of sandstone, hornfels and dolerite which are 0.5-1.5 m in diameter and are of angular to subrounded form. The beach deposits consist predominantly of sandstones, siltstones and mudstones of Triassic-Permian age, with some Jurassic dolerites and occasional quartzites which may have been derived from the Triassic sediments. The deposit is moderately indurated and cemented with iron oxide which locally forms skins on the surface of the boulders. The deposit is weathered and oxidised throughout with the dolerites having a 10-20 mm deep weathering rind. The flattened cobbles and bedding of the deposit dip at 5-10° towards 165°. This indicates that deposition took place when the sea had open access along the geo. At 1.1-1.7m on the northeastern side of the section a pocket of sharp-edged angular hornfels fragments occurs within the beach deposits. These fragments have been derived directly from the adjacent wall of the geo.

The upper part of the exposed section shows two main beds of slope and valley-fill deposits. Near the base of the lower bed are numerous sharp-edged hornfels, dolerite and sandstone fragments set in a greyish-brown fine sandy matrix. The sandstones are moderately weathered. Towards the top, the greyish-brown fine sandy

deposit shows orange-brown mottles and contains occasional sandstone pebbles up to 50 mm in size which are completely weathered. Between 6 and 6.5 m there is a distinct break between the highly weathered and mottled fine sandy deposits of the upper 0.5 m of the lower part of the slope and valley-fill deposits and the overlying largely unweathered light yellow-brown sandy slope and valley-fill deposits with sandstone and sharp-edged hornfels fragments of 20-50 mm size. The clear break and the weathered and mottled character of the fine sandy deposits between 6 and 6.5 m probably indicates a short break in slope deposit accumulation with the development of a gley soil on the valley floor during the interval. This horizon contained poorly preserved charcoal fragments which are probably related to an old soil or ground surface.

At the head of the Remarkable Cave there is a cone-shaped accumulation of sandstone cliff-fall blocks of 1-2 m diameter. Although a cliff-fall scar on the face above indicates that some debris has been added recently to the cone, the very large basal blocks appear to have fallen into the valley head at an earlier time. They probably constitute a remnant of the deposit that filled up the old geo floor.

Several factors need to be considered in an explanation of the origin of the slope and valley-fill deposits. The slope deposits contain numerous sharp-edged fragments yet at the same time contain many strongly weathered sandstone fragments. The sharp-edged fragments are chiefly hornfels and are explained by the alteration and fracturing that took place in the dolerite-sandstone contact zone. The unaltered sandstones are weakly to moderately cemented and would be easily eroded from the steep slopes above and on the margins of the geo to produce the slope deposits. Their weak cementation would facilitate subsequent weathering in the wet conditions of the valley floor.

The valley-fill deposits contain thin beds and laminae of washed and sorted sands which demonstrate water transport along and deposition in the axis of the valley. However, there is no evidence of the presence of a significant stream in the valley and the fibrous and matted organic horizons near the top of the section suggest that it was a damp largely vegetated valley bottom without a permanent streamcourse. While clearly the steep slopes above and the depth of the geo below were important factors in facilitating the accumulation of these deposits they do not account for their erosion. As it is considered (see pollen) that the area was vegetated by scrub, heath, forest/woodland and wet valley scrub associations the ground surface would have been stable for most of the time. The abundant wood fragments in the deposits indicate that this small valley had moderate sized trees probably up to 10-15 m in height at several times. The intimate associations of charcoal, organic detritus and wood in the base of the slope and valley-fill deposits suggests that strong mass movements of slope materials, slopewash and fluvial action caused the erosion of the deposits from the catchment after periods of firing which destroyed not only the vegetation cover but also the binding effects of the surface litter and ground cover. It is possible that after numerous fires and subsequent episodes of erosion that the pre-existing regolith cover had been so severely denuded that parts of the weak sandstones on the steep slopes could not be rapidly recolonised by thick vegetation. This could account for the marked reduction of charcoal and organic detritus in the slope deposits above 4 m on the western side of the seaward section.

DATING

In 1973 a sample of charcoal taken from site X between 100 and 200 mm above the junction of the fossil beach deposits and the overlying slope deposits in the cave section was assayed by the ^{14}C method as being 29,000 ± 2000 BP,(SUA-154) radiocarbon years old. This assay from the base of the slope deposits indicated that all the organic materials found in the seaward section might be within the ^{14}C age range. Samples submitted from horizons A, B and C near the base of the deposit gave infinite

assays of >40,000 BP (SUA-347, 348 and 349) and samples submitted later from horizons H and J also gave infinite assays of >37,000 BP (SUA-389 and 391). The infinite assays on the samples from the seaward section indicate that all the slope and valley-fill deposits are beyond ^{14}C range and point to the sample taken from X as having been contaminated by the downward movement of modern organic acids. Mr R. Gillespie of the Sydney University Radiocarbon Laboratory who dated the samples has informed me that sample SUA-154 did not receive alkali pretreatment before assay whereas the other samples did and agrees that contamination of the sample is likely. The infinite results assist in a limited way in determining the relative and absolute ages of the main landforms and deposits developed at Remarkable Cave.

The geo and buried cobble beach deposit cannot have been formed at a date much later than the end of the Last Interglacial when on coasts primarily influenced by glacio-eustatic changes the sea retreated from its former higher levels. Therefore the formation of the geo and fossil beach probably occurred during the Last Interglacial, but the Remarkable Cave did not then exist in its present form. When sea level fell slope and fluvial processes of erosion operated on the sides of the small valley above the geo and degraded them further while the eroded materials temporarily infilled the geo. The buried beach deposits and ^{14}C dates indicate that the infilling probably occurred between the end of the Last Interglacial and before 40,000 BP, and that during the early part of the Last Glacial Stage significant quantities of organic litter, soil and fractured rock fragments were being intermittently formed and episodically removed from the slopes by erosion. It is unlikely that the formation and removal of similar deposits from these steep slopes ceased to occur after 40,000 BP. The absence of deposits of later age is probably explained by the fact that once the deep geo was filled up with sediments the later deposits would have been moved further seawards across the elevated sloping surface of the already accumulated deposits.

During the Late Last Glacial and early Holocene stages sea level rose until by 6,000 BP it had attained approximately its present level in southeastern Australia (Thom and Chappell 1975). The slope and valley-fill deposits initially excluded the sea from the geo and wave action caused strong erosion along the Remarkable Cave fault plane at the same time as it gradually removed most of the deposits from the geo. The difference in age between the re-excavated geo and the cave is also demonstrated where the cave breaches the southwestern wall of the geo near its head. The walls of the geo are smoothed and slightly weathered but the blocks of rock removed from the wall above the cave exit have left sharp angular edges on the rock surface. Thus, the geo was primarily a product of marine erosion on this steep coast during the Last Interglacial while the greater part of the Remarkable Cave appears to have been formed during the Middle and Late Holocene.

POLLEN ANALYSIS

Samples A-L were collected from the organic and charcoal rich horizons in the seaward section of the slope and valley-fill deposits. The samples were processed by the Faegri and Iversen technique (1964), and relative counts based on sums of 200 grains of all pollen excluding the spores of *Dicksonia antarctica* and *Cyathea* were made. These spores are expressed as a percentage of the terretrial pollen. The pollen types were identified by comparison with reference slides of modern pollen in the collection of the Botany Department of the University of Tasmania. The taxonomic nomenclature follows Curtis (1956, 1963, 1967). The percentages are given in table 1.

Because of the problems associated with transported organic materials that contain pollen derived from older surface litters and soil materials (Havinga 1974; Riezebos and Slotboom 1974) the work was carried out only to get a general impression

TABLE 1

POLLEN PERCENTAGES FROM REMARKABLE CAVE

Vegetation	Pollen Group	A	B	C	D	E	F	G	H	I	J	K	L	
ALPINE AND SUBALPINE	*Pherosphaera hookeriana*	+	+	+										
	Podocarpus								+					
TEMPERATE RAIN FOREST	*Dacrydium franklinii*		+											
	Nothofagus cunninghamii	1.8	2.2	?	+	+	1.8	4.9	3.8	+	+	1.9	2.0	
	Phyllocladus asplenii folius	2.3	3.9	2.2	+		+	+	+	1.9	+	+	1.5	
	Acacia			?			1.3	+	+		+	+		
	Banksia marginata	+	1.7	2.8	+	+	1.8	1.5	1.9	1.4	1.4		6.9	
	Casuarina spp.	+	+	+	2.9	3.8	2.7		+	6.0	8.6	4.7	8.3	
	Compositae	22.6	25.8	12.9	10.2	2.4	12.1	12.2	7.6	10.2	6.7	6.6	8.8	
	Dodonaea												+	
	Drimys lanceolata	?	3.0	+	1.0		?			+			+	
TREES AND SHRUBS	Epacridaceae	1.4	1.3	+	2.0	1.4	+	3.4	1.9	3.2	2.9	2.8	13.7	excl.
	Eucalyptus spp.	20.8	12.7	27.7	14.1	21.5	8.9	9.3	16.2	7.8	22.5	23.2	23.5	*Monotoca*
	Leptospermum spp.	5.4	3.9	12.0	36.1	52.2	15.6	19.0	26.5	30.6	30.0	45.5	8.1	
	Melaleuca spp.	18.1	7.4	17.0	4.9	5.7	4.0	3.9	3.3	3.7	3.8	7.6	7.4	
	Monotoca	+	+	+	1.0	+	3.1	2.0	1.4	+	+	2.4	3.4	
	Pomaderris apetala	11.8	10.0	10.6	5.8	1.4	9.8	13.2	7.6	11.1	5.7	1.4	4.9	
	Pittosporaceae				+	+								
	Rhamnaceae	8.6	17.1	9.2	2.4	3.4	17.4	24.8	14.7	4.6	11.1	+	+	excl.
	Rutaceae				6.8		+						*Pomaderris apetala*	
	Chenopodiaceae		+				+						1.5	
	Cyperaceae	1.8	2.2		2.4	+	6.3	+	+	5.1	1.9	+	2.9	
HERBS	Gramineae	3.2	3.9	+	2.0	1.4	2.2	5.9		7.9	1.9	+	2.0	
	Haloragaceae				+					1.4				
	Onagraceae				1.0						+			
	Portulacaceae			+	+									
	Restionaceae				+	+	+							
	Umbelliferae	?	+		+	+	?				+			
	Unknowns	1.8	2.6	+	2.9	+	10.7	+	11.0	2.8	+	+	5.25	
	Total	221	229	217	205	210	224	205	211	216	209	211	224	
TREEFERNS	*Dicksonia antarctica* plus *Cyathea* sp.	2.3	12.2	+	49.3	31.4	49.5	9.8	42.2	18.1	30.1	10.4	54.9	

+ <1%

of the nature of the vegetation and plant groups that occupied the area while the deposits were accumulating and not for the purpose of determining systematic changes of the vegetation through time.

The present vegetation of the Remarkable Cave and adjacent Brown Mountain area varies from low *Eucalyptus* woodland to closed-scrub dominated by *Leptospermum* spp. with abundant *Melaleuca* spp. and open-scrub dominated by *Leptospermum* spp. There are also areas of closed-heath with *Leptospermum*, *Banksia* and *Melaleuca*, open-heath with *Leptospermum*, *Banksia* and epacridaceous species, and local areas of grassland and herbland (Jackson, in Specht *et al*. 1974). The vegetation of the area is subject to frequent firing which helps to maintain the scrub and heath communities. The present vegetation of the small catchment at Remarkable Cave is open-heath but in the bottom of adjacent valleys *D. antarctica* and *Pomaderris apetala* , typical of the understory of fire ravaged tall open (wet sclerophyll) forests, are common (Specht *et al*. 1974).

The traces of alpine and subalpine pollen (table 1.) have been transported a long distance and are unlikely to indicate the presence of these species in the area during this time. The low values for the temperate rain forest species are also consistent with long distance transport to the site from southwestern Tasmania, but it is possible that some of the *Nothofagus cunninghamii* and *Phyllocladus asplenifolius* pollen may be of local origin from the southern part of the Tasman Peninsula.

The pollen of the main tree and shrub groups is probably mainly local with the possible exceptions of *Banksia* and *Casuarina* which are easily transported, and *Drimys lanceolata* which is probably non-local.

The major components of the vegetation throughout the period consisted of species of Myrtaceae and Rhamnaceae with subsidiary Compositae, all of which must have been growing extensively in the local area. The percentage values for the Myrtaceae groups vary considerably from horizon to horizon but between D and K *Leptospermum* pollen is the chief component with 17-52 per cent. In horizons A to C and L the *Leptospermum* pollen becomes the least of the myrtaceous groups and is exceeded by *Eucalyptus* (23-28%) and *Melaleuca* (7-18%) components. Pollen of the Rhamnaceae, especially *P. apetala*, seems to have been more abundant than in the region today and on horizons B, F and G pollen of Rhamnaceae exceeds that of Myrtaceae with percentages of 27 to 38. Compositae pollen, probably chiefly of shrub species, is the main component in horizons A and B, but is an important subsidiary component of all horixons. Percentages of Epacridaceae including *Monotoca* are low except in horizon L. Gramineae, Cyperaceae, and herb values are low, only occasionally exceeding 5 per cent. The values for *D. antarctica* plus *Cyathea* fluctuate strongly from horizon to horizon from <1 to 55 per cent.

It is not possible to draw a single conclusion on the type of vegetation reflected by the pollen in the local area as the pollen rain probably represents a mixed assemblage drawn from several local vegetation associations that are similar to the associations in the area today. The spectral assemblages suggest that *Eucalyptus* forest/woodland, *Leptospermum-Eucalyptus-Melaleuca* scrub with Compositae, and *Leptospermum*-Compositae heath occupied various areas. The abundant Rhamnaceae and variable *Dicksonia* components are consistent with wet-scrub vegetation along the damp floors of small valleys. Grassland and herbland associations were unimportant and probably only occupied very restricted areas.

The charcoal in the slope and valley-fill deposits indicates that the suggested vegetation associations were strongly influenced by fire during this time and this environmental factor would have favoured the maintenance of a *Leptospermum-Melaleuca*-Compositae scrub or heath during the fire intervals. Although it is not possible to

detect any successional trends from the pollen spectra, the significant *Eucalyptus P. apetala* and *D. antarctica* components suggest that in the absence of frequent firing the vegetation would have developed towards a tall open (wet sclerophyll) forest. It is also possible that the increase in *Casuarina* on horizons I to L and the higher values for *Banksia* and Epacridaceae on horizon L reflect an increase of heath low-shrubland vegetation in this small valley consequent upon firing and erosion in the catchment. The pollen evidence suggests that the vegetation of the area during most of the early part of the Last Glacial was similar in composition to that in the area today, but its density is difficult to assess.

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A LATE MIDDLE CAMBRIAN FAUNA FROM THE QUE RIVER BEDS, WESTERN TASMANIA

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(with one table and three plates)

ABSTRACT

A late Middle Cambrian (*Ptychagnostus punctuosus* or *P. nathorsti* Zone) fauna occurs in the Que River Beds, Western Tasmania. Hydroids, dendroids and a possible aglaspid have been described previously. The remaining fauna of ten species of agnostid trilobites, one species of acrotretid brachiopod, various sponge spicules and one bradoriid specimen is described herein. The fauna is unusual in that no polymerid trilobites are known and that there is a very high percentage of complete agnostid specimens. One new agnostid species *Ptychagnostus* (?) *murchisoni* is described. One probable new agnostid genus and one probable new species of *Diplagnostus* are left in open nomenclature, because of their poor preservation.

INTRODUCTION

The late Middle Cambrian fauna, described below, from the Que River Beds of Western Tasmania (lat. 41°34.7'S, long 145°41.0'E) is important both from a biostratigraphic and palaeoecologic view point. It is significant biostratigraphically because it is one of only two faunas found within the economically important Mt Read Volcanics. Gee *et al.* (1970) gave details of the location and stratigraphic relationships of the Mt Read Volcanics and the Que River Beds. The Que River fauna consists of hydroids and dendroids (Quilty 1971), a species of inarticulate brachiopod (*Linnarssonia (?)* sp.), sponge spicules and agnostid trilobites (table 1) in reasonable abundance. A single specimen of a possible aglaspid was described by Quilty (1972); one bradoriid specimen is described below. No polymerid trilobites are known from the Que River Beds. Jago (1973) discussed some palaeoecological aspects of the Que River fauna. As noted previously, a striking feature of this fauna is the very high proportion of complete agnostid specimens (table 1).

The agnostids listed in table 1 indicate a late Middle Cambrian age. In Sweden *Ptychagnostus stenorrhachis* occurs in both the *P. punctuosus* and *P. nathorsti* Zones (Westergård 1946). In Newfoundland, Hutchinson (1962) described *stenorrhachis* from the upper part of the *Paradoxides davidis* Zone, which is of similar age to the *P. punctuosus* Zone of Sweden. Although none of the other agnostids give precise ages, the overall assemblage indicates agreement with an age of either *P. punctuosus* Zone or the *P. nathorsti* Zone for the Que River Beds.

The Que River fauna, like all Tasmanian Cambrian faunas has undergone tectonic distortion. The terminology of distorted bilaterally symmetrical fossils (e.g., trilobites and brachiopods) was discussed by Henningsmoen (1960); the same terminology is used in this paper as in Jago (1976). All trilobites and brachiopods from the Que River Beds are preserved as internal and external moulds in weathered siltstone. Some of the sponge spicules retain their original siliceous material. Silicone rubber casts were made of external and internal moulds of the various fossil groups. These casts were then photographed after being whitened with magnesium oxide. The inarticulate brachiopod, bradoriid and agnostid classifications used below are those of Rowell (1965), Öpik (1968) and Öpik (1967), respectively. All catalogue numbers refer to the collection of the Geology Department, University of Tasmania.

SYSTEMATIC DESCRIPTIONS

Phylum PORIFERA Grant 1872

Numerous sponge spicules occur in the Que River Beds. Three main types of spicules are present:

(1) Very long monaxons up to 60 mm long (Pl. 3, fig. 5). These have longitudinal striations.
(2) Tetraxons in which the four rays have a tetrahedral relationship with one ray being considerably longer than the other three (Pl. 3, fig. 3). There is a suggestion of longitudinal striations on the longest ray.

TABLE 1

ANALYSIS OF AGNOSTID TRILOBITES FROM QUE RIVER BEDS AT QUE RIVER BRIDGE

(lat. 41°34.7'S, long. 145°41.0'E)

In this table each individual cephalon or pygidium is counted as one unit; a complete agnostid has two units.

	Complete Specimens	Separate Cephala	Separate Pygidia	Total No. Specimens	Total Cephala & Pygidia
Hypagnostus sp. aff. *H. parvifrons* (Linnarsson)	2	-	-	2	4
Grandagnostus (?) sp.	2	-	-	2	4
cf. *Valenagnostus* sp.	1	-	-	1	2
Ptychagnostus stenorrhachis (Grönwall)	4	5	8	17	21
Ptychagnostus sp.	2	-	-	2	4
Ptychagnostus (?) *murchisoni* sp. nov.	14	12	16	42	56
Diplagnostus sp.	3	2	5	10	13
cf. *Kormagnostus* sp.	2	1	-	3	5
Agnostid, gen. et sp. indet. no. 1	-	-	1	1	1
Agnostid, gen. et sp. indet. no. 2	-	-	1	1	1
Very poorly preserved unidentifiable specimens, 5 complete specimens, 5 individual cephala or pygidia				10	15
					126
Total number of cephala and pygidia			126		
Number of cephala and pygidia in complete specimens			70		
Percentage of cephala and pygidia in complete specimens			55.6%		

(3) Cruciform stauracts (Pl. 3, figs. 1,2 and 4) are by far the most common type of spicule. Individual stauracts have a cross-like arrangement of rays, with the centre of the cross being markedly elevated above the plane of the gently curved rays (Pl. 3, fig. 4). However, there is no evidence of a polar ray as seen in *Protospongia*? sp. of Henningsmoen (1958, Pl. 7, figs. 4-6) and in *Pleodioria tomacis* Öpik (1961, P. 49, fig. 16). There are at least two orders of stauracts (Pl. 3, figs. 1 & 2) with the first order spicules overlying the second order spicules. Within the first order spicules there is some variation, with some spicules having long thin rays, while others have shorter, thicker rays (Pl. 3, figs. 1 & 2). The Que River stauracts belong in *Protospongia*, the best described species of which is *P. hicksi*, which has been well illustrated from the Middle Cambrian of Utah (Rigby 1966) and from possible Middle Cambrian rocks in Ireland (Rushton and Phillips 1973). However, until larger and better preserved specimens are found, no species designation should be given to the Que River form of *Protospongia*.

Phylum BRACHIOPODA Dumeril 1806
Class INARTICULATA Huxley 1869
Order ACROTRETIDA Kuhn 1949
Suborder ACROTRETIDINA Kuhn 1949
Superfamily ACROTRETACEA Schuchert 1893
Family ACROTRETIDAE Schuchert 1893
Subfamily LINNARSSONIINAE Rowell 1965
Genus *LINNARSSONIA* Walcott 1885
Linnarssonia (?) sp.
Plate 3, figs. 7-15

Remarks: All the poorly preserved inarticulate brachiopod specimens from the Que River Beds appear to belong to a single species, probably of *Linnarssonia*. In all specimens the valves are decorticated.

On the brachial valve interior, there is a prominent median ridge extending from the posterior to about the centre of the valve. The ridge widens towards the centre of the valve. The only muscle scars seen on any specimens are those on the counterparts UT95164 and UT95165 (Pl. 3, figs. 9, 10). Here, almost half-way along the median ridge, there is a pair of small, kidney-shaped anterior muscle scars. All known pedicle valves are very poorly preserved and no features of the interior of the valve can be seen.

Phylum ARTHROPODA Siebold and Stannius 1845
Class TRILOBITA Walch 1771
Order MIOMERA Jaekel 1909
Suborder AGNOSTINA Salter 1864
Superfamily AGNOSTACEA M'Coy 1849
Family AGNOSTIDAE M'Coy 1849
Subfamily QUADRAGNOSTINAE Howell 1935
Genus *HYPAGNOSTUS* Jaekel 1909

Synonymy: See Jago 1976, p. 140.
Type Species: *Agnostus parvifrons* Linnarsson, 1869, p. 82, pl. 2, figs. 56, 57.
Diagnosis: See Robison 1964, p. 529.

Hypagnostus sp. aff. *H. parvifrons* (Linnarsson)
Plate 1, figs. 1, 2

Westergård (1946, p. 45) and Robison (1964, p. 529) gave the synonymy of *H. parvifrons*.

Material: Two small, almost complete specimens are available.

Description: Cephalon about as wide as is long. Moderately wide rim only slightly elevated above narrow, shallow marginal furrow. Single-lobed glabella has a gently arched, almost truncated front. Glabella outlined by shallow wide furrows; it has a length just over 0.4 that of cephalon. Very small basal lobes. Distinct node on glabella of UT95148 but not on UT92496 where there is a prominent high area in the posterior and central parts of the glabella. This difference is probably due to distortion. Broadly rounded glabellar rear.

Pygidium about as wide as is long. Wide border with a wide rim and narrow, shallow marginal furrow. Pygidial axis extends just over 0.7 the length of the pygidium. Axis stands well above the smooth pleural fields, which are separated behind the posterior end of axis by a depressed area. Width of axis at anterior is just under half that of pygidium. Axis is slightly constricted at join of first and second axial lobes; it is widest at about its midpoint. Sharply rounded almost pointed axial posterior. Anterior transverse axial furrow is best developed laterally and can be traced faintly across axis. Second transverse furrow seen only at lateral extremities. Length of posterior axial lobe is about two-thirds that of axis. Pygidial axis shows no distinct node on second axial lobe (possibly due to distortion). There may be a prominent node at the posterior tip of axis. The apparent node seen in both specimens (Pl. 1, figs. 1 and 2) may be due to distortion, but the fact that the node has a similar shape in both specimens probably indicates a genuine feature.

Discussion: The species from the Que River Beds is similar to *H. parvifrons* in that it has a short, rather truncated cephalon, and a strongly convex pygidial axis which does not extend as far to the posterior as do the pleural fields. It is also similar to *parvifrons* in that the transverse axial furrows are poorly developed. The profile of the pygidial axis is similar to that of *H. parvifrons mammillatus* (Brögger) illustrated by Westergård (1946, pl. 5, figs. 3b, 4b). There is no distinct node on the second pygidial axial lobe in the Que River specimens; this feature may have been obliterated by distortion. The basal lobes of the Que River species appear to be even smaller than the small basal lobes of *H. parvifrons* from Sweden and Utah as illustrated by Westergård (1946) and Robison (1964). The cephala of *H. parvifrons* from both Sweden and Utah have a distinct connecting band between the basal lobes; the presence or absence of this feature cannot be determined in the Que River specimens. There may be a prominent terminal pygidial axial node on the Que River forms; such a feature is not seen on *H. parvifrons*.

Genus *GRANDAGNOSTUS* Howell 1935

Synonymy: See Jago 1976, p. 141.
Type Species: *Grandagnostus vermontensis* Howell, 1935, p. 221, pl. 22, figs. 8-11.
Diagnosis See Jago 1976, p. 141.

Grandagnostus (?) sp.
Plate 1, figs. 3, 4

Material: Two poorly preserved enrolled specimens of a large agnostid are available: UT 92654 shows the pygidium and UT 92653 exhibits the cephalon.

Description: The cephalon of UT 92653 is subquadrate (about 5.5mm long and 6.0mm wide) with apparently entirely effaced surface. Moderately wide border area with shallow marginal furrow and elevated rim. Pygidium probably has a subquadrate outline. Moderately wide marginal furrow; rim not preserved. Axis well outlined at anterior by deep dorsal furrows which fade posteriorly. At anterior margin, width of axis is about half that of pygidium. Axis narrows posteriorly until it is narrowest about 0.25 of distance to posterior margin. To posterior of narrowest part, axis widens slightly and fades out. Smooth pleural fields.

Discussion: The size and high degree of effacement of this species suggests affiliation with *Grandagnostus*, but until better specimens are found no definite generic assignment can be made.

Genus *VALENAGNOSTUS* Jago 1976

Valenagnostus Jago 1976, p. 142.
Type species: *Agnostus nudus* Beyrich var. *marginata* Brögger, 1878, p. 773, pl. 6, fig. 3.
Diagnosis: See Jago 1976, p. 142.

cf. *Valenagnostus* sp.
Plate 1, figs. 5, 6

Material: One specimen, UT 92499, is available. It is an external mould in which the cephalon and pygidium are present but with no sign of the thorax, which was probably pushed under the pygidium during distortion. The cephalon and pygidium are both 2.0mm long and 2.2mm wide and have maximum heights of 0.6mm and 0.3mm respectively.

Description: Moderately convex cephalon with semicircular outline and straight posterior margin. No evidence of border, except possibly in left posterolateral corner, but this feature could be due to distortion. Surface of cephalon almost entirely effaced; faint axial furrows outline the rounded posterior end of a narrow glabella. Faint traces of small, separate basal lobes.

Pygidium has "subtriangular" outline; it is much flatter than cephalon (Pl. 1, fig. 6). Wide posterior border with wide, shallow marginal furrow and wide flatly convex rim; border narrows markedly anteriorly. Narrow shallow shoulder furrows; narrow convex shoulders. Length of the unconstricted acrolobe about five-sixths that of pygidium. Acrolobe may be entirely effaced, but there is a suggestion of a wide axis at extreme anterior end of pygidium.

Discussion: This specimen is similar to *Valenagnostus* in that both the cephalon and pygidium are almost entirely effaced, and there is a wide posterior pygidial border which narrows considerably to the anterior. If a cephalic border exists on cf. *Valenagnostus* sp., then it must be very narrow. The anterior axial trace on the pygidium of cf. *Valenagnostus* sp. is wider than the anterior part of the axis on any known species of *Valenagnostus*. There is no sign of a terminal axial node on cf. *Valenagnostus* sp., a feature which is seen in *Valenagnostus*. The difference in convexity of the acrolobes of the cephalon and pygidium of cf. *Valenagnostus* sp. is markedly greater than in any known species of *Valenagnostus*.

Subfamily PTYCHAGNOSTINAE Kobayashi 1939
Genus *PTYCHAGNOSTUS* Jaekel 1909

Synonymy: See Robison 1964, p. 522 and Jago 1976, p. 150.
Diagnosis: See Robison 1964, p. 522.
Type Species: *Agnostus punctuosus* Angelin 1851, p. 8, pl. 6, fig. 11.

Ptychagnostus (Ptychagnostus) stenorrhachis (Grönwall)
Plate 1, figs. 7-12

Synonymy: See Hutchinson 1962, p. 80.
Diagnosis: Cephalon with slightly scrobiculate cheeks and complete preglabellar median furrow. On the cheeks, there is a pair of short, faint furrows opposite the front of the anterior glabellar lobe, which curve obliquely forward parallel to the dorsal furrow, and join the preglabellar furrow. Transverse glabellar furrow bent slightly forward near centre. Small basal lobes.

Pygidium characterised by narrow axis constricted at second axial lobe. Prominent backwards directed spine on second axial lobe. There is a faint post-axial median furrow. Smooth pleural areas. Border spines absent.

Discussion: In discussing *P. stenorrhachis* from Newfoundland, Hutchinson (1962, P. 81) noted, "a pair of short, indistinct furrows opposite the front of the anterior glabellar lobe, which curve obliquely forward parallel to the dorsal furrow, and join the preglabellar furrow." Similar furrows occur in the cephalon figured by Westergård (1946, pl. 10, fig.3), in the Que River specimens (Pl. 1, figs. 7, 8, 10), and appear to be a specific character (Hutchinson 1962). An inspection of photographs and rubber casts of many other species of *Ptychagnostus* failed to produce similar furrows, thus supporting Hutchinson's view. Some Que River specimens (e.g. UT 92504, Pl. 1, fig. 8 and UT 92506, Pl. 1, fig. 7) show a little more cephalic scrobiculation than on the specimen figured by Westergård.

The post-axial median furrow is only faintly outlined in the pygidium figured by Westergård (1946, Pl. 10, fig. 4). However, in a rubber cast of this specimen, which is available to the writer, this furrow, although faint, is quite distinct and is strongest at the anterior. The least distorted of the Que River specimens (Pl. 1, fig. 11) shows a similar furrow. The fulcra of *stenorrhachis* in both the Swedish and Newfoundland forms are in a similar position to those in the Que River specimens. A characteristic feature of *stenorrhachis* is the marked backward arching of the central part of the second axial lobe; this feature is present in the Que River specimens. A further feature indicating that the Que River specimens belong in *stenorrhachis* is the long, thin nature of the pygidial axis. A similar feature is seen in *P. hybridus* (Brögger), but the cephalon of this species is not scrobiculate.

Cobbold and Pocock (1934, pl. 44, fig. 22) figure a pygidium from Rushton, England as *Agnostus stenorrhachis* Grönwall. However, their figure is inadequate for comparative purposes, and the specific designation must remain open at present.

Ptychagnostus sp.

There are two unfigured, very poorly preserved, specimens of *Ptychagnostus* which do not appear to belong in *P. stenorrhachis*.

Ptychagnostus (?) murchisoni sp. nov.

Plate 1, figs. 13-15; plate 2, figs. 1-6

Diagnosis: Large agnostid in which both the cephalon and pygidium are moderately convex and slightly wider than long. Almost entirely effaced cephalon with faint node just to posterior of its midpoint. Narrow cephalic border is a little narrower than pygidial border. Basic articulating device; fulcral points close to axis. Trilobed pygidial axis is outlined by shallow axial furrows which fade posteriorly. Axis constricted at second lobe which bears a low node. No post-axial median furrow; border spines absent.

Material: Fourteen complete or almost complete specimens, plus several individual cephala and pygidia are available. UT 92508 (Pl. 2, fig. 2) is selected as holotype.

Description: Moderately convex, almost entirely effaced cephalon is slightly wider than long. Low, small node occurs a little to posterior of cephalic centre. Narrow border, with narrow shallow marginal furrow and narrow convex rim. Short posterolateral spines. Vestigial traces of basal lobes in some specimens (e.g. UT 92508, Pl. 2 fig. 2.). There appear to be traces of axial furrows in UT 92510 (Pl. 1, fig. 15) although these could be due to distortion.

Moderately convex pygidium slightly wider than long. Narrow border with narrow, slightly convex rim and narrow marginal furrow. Narrow, moderately shallow shoulder furrows; narrow shoulders; fulcral points close to axis. Basic articulating device has a narrow, moderately deep, articulating furrow; low, convex articulating half-ring. Axial furrows faintly but clearly developed and are accentuated by distortion;

they shallow posteriorly. Trilobed axis extends about 0.75 length of pygidium. Posterior lobe is longer than the two anterior lobes combined. Axis is constricted at second lobe. At its widest, axis is just under half the width of pygidium. Second lobe bears a distinct, elongated node. Border spines absent.
Discussion: *Ptychagnostus (?) murchisoni* sp. nov. is of a similar type to both *P. ciceroides* (Matthew) and *P. convexus* Westergård. In both these large species, the cephalon and pygidium are highly convex; the cephalon is partly effaced; the transverse pygidial axial furrows are somewhat effaced, and there are no border spines or post-axial median furrow on the pygidium.

Some cephala of *P. convexus* show faint scrobiculation (Westergård, 1946, p. 73). It is difficult to determine from the photographs of *P. ciceroides*, given by Hutchinson (1962, pl. 10, figs. 1, 2, 8), whether this species has a faintly scrobiculate cephalon. However, *P. ciceroides* from Greenland, as figured by Poulsen (1969, p. 5, fig. 5), shows no sign of scrobiculation. The cephalon of *P.(?) murchisoni* is not scrobiculate. *P. convexus* and *P. ciceroides* are probably more convex than *P.(?) murchisoni* even allowing for the distortion of the latter. *P.(?) murchisoni* is much more effaced than *P. convexus*. *P.(?) murchisoni* is closer to *P. ciceroides* than *P. convexus*. It is a little more effaced than *ciceroides*, and the posterior end of the pygidial axis in *murchisoni* is usually almost obliterated whereas in *ciceroides* it is distinctly visible except in the specimen figured by Hutchinson (1962) as pl. 10, fig. 7.

The species from Que River is referred to *Ptychagnostus* with a query due to the effaced nature of the cephalon. The pygidium is similar to those of *Ptychagnostus (Ptychagnostus)*. If *murchisoni* and *ciceroides* are to be included in *Ptychagnostus*, then the diagnoses of the genus given by Robison (1964, p. 522) and Palmer (1968, p.28) will have to be revised and the generic character based largely on the pygidium. The writer agrees with Hutchinson (1962, p. 85) and regards such species as *ciceroides* and *murchisoni* as being in an evolutionary line in the process of effacement. The writer also agrees with both Hutchinson (1962, p. 88) and Poulsen (1969, p. 6) that the erection of a new genus is unnecessary at this stage.

Family DIPLAGNOSTIDAE Whitehouse 1936

Subfamily DIPLAGNOSTINAE Whitehouse 1936

Genus *DIPLAGNOSTUS* Jaekel 1909

Synonymy: See Jago 1976, p. 158.
Type species: *Agnostus planicauda* Tullberg 1880 (*non* Angelin 1851)
Diagnosis: See Öpik 1961, p. 69.

Diplagnostus sp.
Plate 2, figs. 7-12

Material: Three more or less complete specimens and several isolated cephala and pygidia are available. All are poorly preserved.
Description: Cephalon a little wider than is long. Wide, moderately deep marginal furrow at posterior, which becomes shallow and very wide at anterior. Narrow, elevated rim. Short, triangular, upturned posterolateral spines. Convex cheeks may be pitted to some extent although the distortion makes such a determination doubtful. Glabella is about two-thirds as long as cephalon and about one-third the width. Narrow, moderately deep axial furrows; shallow, straight transverse glabellar furrow. Moderate sized basal lobes. Preglabellar median furrow appears to be absent in UT 95154 (Pl. 2, fig. 7), but in UT 92617 (Pl. 2, fig. 11) and UT 89198a (Pl. 2, fig. 8) a short furrow appears to be there. Anterior glabellar lobe contains a median sulcus which extends about one-third the length of the lobe. Glabella widens slightly anteriorly; it is widest just posterior of transverse glabellar furrow. Length of anterior glabellar lobe about .25 that of glabella. Details of posterior glabellar lobe obscured by

distortion. Glabellar rear angular.

Pygidium probably slightly wider than is long. Wide marginal furrow becomes very wide near posterolateral corners; convex narrow rim. Zonate posterior border with collar reaching rim at either end. Collar arched gently to posterior except at either extremity where it is arched very slightly to anterior. It meets the rim just to anterior of short border spines. Narrow, moderately deep shoulder furrows; narrow shoulders; fulcra close to axis. Smooth pleural areas. Axis outlined by moderately deep furrows; axis does not reach collar; bluntly pointed axial rear; well-defined post-axial median furrow. Axis consists of three lobes. Axis slightly constricted at second lobe. Anterior pair of lobes make up a little less than half the length of axis. This pair of lobes is outlined by poorly developed transverse furrows which are directed inwards and slightly forwards from the axial furrows. Well defined axial keel extends from anterior of axis along the first two lobes and just onto the third. About one-third of the distance along the posterior axial lobe from the anterior there is a suggestion of a pit on either side of the centre of the axis.
Discussion: This species differs from all other described species of *Diplagnostus* by the presence of very wide marginal furrows. However, the poor quality of the available material precludes the erection of a new species.

Subfamily AMMAGNOSTINAE Öpik 1967

Genus *KORMAGNOSTUS* Resser 1938

Synonymy: See Palmer 1954, p. 59. In addition see Hupé, 1953, p. 65 and Howell 1959, p. 185.
Diagnosis: See Palmer 1954, p. 59.
Type species: *Kormagnostus simplex* Resser, 1938, p. 49, pl. 9, figs. 11-13.

cf. *KORMAGNOSTUS* sp.

Plate 2, figs. 13, 14.

Material: Two badly distorted complete internal moulds, UT 92629 and UT 92630, are available, plus a poorly preserved external mould of a cephalon (UT 89198).
Description: Cephalon about as wide as is long. Narrow, weakly convex rim; moderately wide marginal furrow. Unconstricted acrolobe. Single lobed glabella outlined by moderately deep and wide axial furrows. Glabella has an elongated oval shape with a bluntly rounded anterior. Small basal lobes. Smooth cheeks.

Pygidium about as wide as is long. Wide marginal furrow and moderately wide rim; both features narrow anteriorly. Moderately deep shoulder furrows; well rounded shoulders; adaxially placed fulcra. Acrolobes appear slightly constricted. Very wide axis outlined by narrow axial furrows. Axis is slightly constricted towards anterior; from this constriction it expands posteriorly; the axial furrows meet the marginal furrows about two-thirds of the distance from the pygidial anterior to well-rounded pygidial posterior. May be a small node on central anterior part of axis. Small smooth pleural areas.
Discussion: The species described above probably represents a new genus. However, the specimens are so poorly preserved that the erection of a new genus must be deferred until better material is available.

This species is related to *Kormagnostus* by virtue of its very wide pygidial axis, the probable constriction of the pygidial acrolobe combined with the non-constriction of the cephalic acrolobe, and the wide pygidial border. However, where the transverse glabellar furrow of *Kormagnostus* is straight, the glabellar front of cf. *Kormagnostus* sp. is well rounded. Whether in fact the transverse glabellar furrow of cf. *Kormagnostus* sp. is effaced or represented by the apparent glabellar front cannot be determined from the available material. *Kormagnostus* also differs from cf. *Kormagnostus* sp. in that the latter has a much wider pygidial axis. As with *Kormagnostus*, cf. *Kormagnostus* sp. belongs in the Ammagnostinae, and since it belongs in either the *Ptychagnostus*

punctuosus or the *P. nathorsti* Zone, it is the oldest known member of the subfamily.

Family and Subfamily Unknown

Agnostid, gen. et sp. indet.no. 1
Plate 2, fig. 15

Material: One poorly preserved pygidium, UT 95156
Remarks: This specimen may belong in *Hypagnostus* or *Peronopsis*, although the border area seems too wide for either genus.

Agnostid, gen. et sp. indet.no. 2
Plate 2, fig. 16

Material: One small pygidium, UT 95157
Description: Small pygidium. Wide border narrows anteriorly. Narrow shallow marginal furrow and wide convex rim. Moderately wide axis is faintly outlined by shallow dorsal furrows which disappear posteriorly. Lateral furrows only faintly outlined; axis is markedly constricted at second axial lobe. Third axial lobe appears to be greatly expanded. Axial posterior not visible. Smooth pleural areas.
Discussion: This pygidium, with an expanded third axial lobe (?pseudolobe) does not fit into any known late Middle Cambrian agnostid genus. Until more specimens are found its relationships must remain unknown.

Class CRUSTACEA Pennant 1777

Order BRADORIIDA Raymond 1935

Gen. et sp. indet.
Plate 3, fig. 6

Remarks: One very poorly preserved valve is available as an internal mould. It may be a left valve but this cannot be determined with certainty. The surface of the test is finely pustulose. The rim is moderately wide; the hinge appears to be straight. The very poor preservation precludes an accurate generic or species determination.

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PLATE 1

All figures, except Figs. 10 & 15 are rubber casts of external moulds, which have been whitened with magnesium oxide prior to photography. Figs. 10 & 15 are internal moulds.

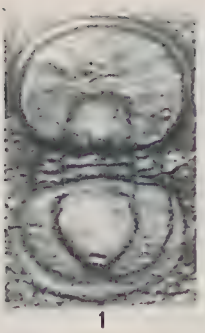
Figs. 1-2 — *Hypagnostus* sp. aff. *H. parvifrons* (Linnarsson). 1 UT92496, complete specimens, W form, X13.7. 2 UT95148, complete specimen, L form, X10.

Figs. 3-4 — *Grandagnostus(?)* sp. 3, UT92653, enrolled specimen with cephalon visible, intermediate distortion, X6, 4, UT92654, enrolled specimen with pygidium visible, W form, X5.5.

Figs. 5-6 — cf. *Valenagnostus* sp. Both figures are of UT 92499.5, top view, W form, X10.5. 6, side view showing cephalon has much greater convexity than pygidium, X10.5.

Figs. 7-12 — *Ptychagnostus (Ptychagnostus) stenorrhachis* (Grönwall). 7, UT92506, partially broken up, almost complete specimen, W form, X6.8. 8, UT92504, cephalon, W form, X5.5. 9, UT95149, pygidium, W form, X8.5. 10, UT92503, cephalon, L form, X8.3. 11, UT92505, pygidium,L Form, X6. 12, UT95150, pygidium, W form, X4.5.

Figs. 13-15 — *Ptychagnostus(?) murchisoni* sp. nov. 13, UT95151, pygidium, W form, X7. 14, UT89205, pygidium and two thoracic segments, W form, X6. 15, UT92510, cephalon, L form, X8.3.



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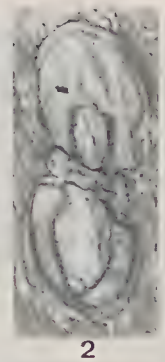

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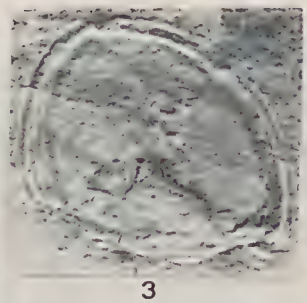

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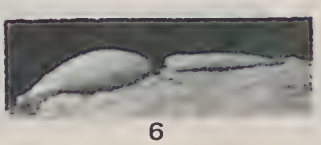

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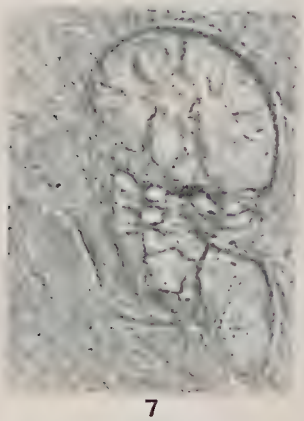

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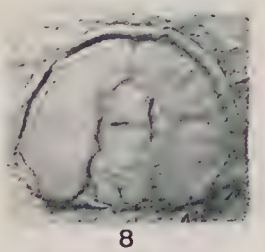

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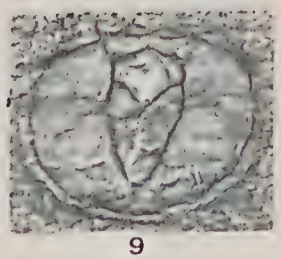

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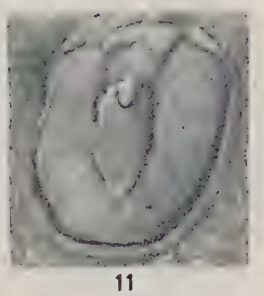

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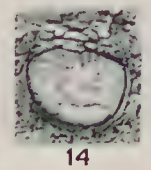

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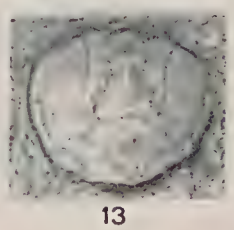

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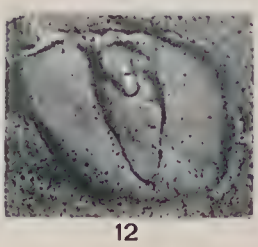

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PLATE 2

Unless otherwise stated all figures are rubber casts of external moulds, which have been whitened with magnesium oxide prior to photography.

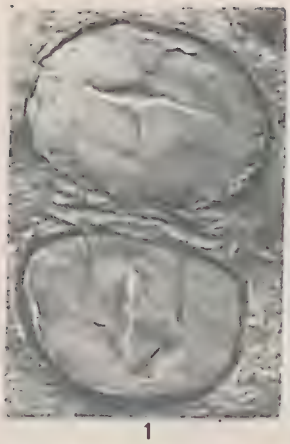
Figs. 1-6 — *Ptychagnostus(?) murchisoni* sp. nov. 1, UT92509, complete specimen, W form, X6.5. 2, UT92508, holotype, complete specimen, L. form, X10. 3, UT92507, complete specimen, L. form, X4.2. 4, UT95152, cephalon, W form, X6.5. 5, UT89211, internal mould of pygidium, W form, X8, 6, UT95153, pygidium, intermediate distortion, X4.5.

Figs. 7-12 — *Diplagnostus* sp. 7, UT95154, cephalon, intermediate distortion, X9.5. 8, UT89198a, complete specimen, L. form, X6. 9, UT95155, internal mould and pygidium, intermediate distortion, X9.3. 10, UT89207, pygidium, intermediate distortion, X6.2. 11, UT92617, almost complete specimen, L. form, X4.5. 12, UT92616, internal mould of pygidium, intermediate distortion, X11.5.

Figs. 13-14 — cf. *Kormagnostus* sp. 13, UT92630, complete internal mould, L form, X12. 14, UT92629, complete internal mould, W form X13.3.

Fig. 15 — Agnostid, gen. et sp. indet. No. 1, UT95156, pygidium, L form, X5.

Fig. 16 — Agnostid, gen. et sp. indet. No. 2, UT95157, pygidium, W form, X8.5.



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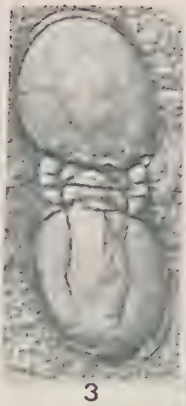

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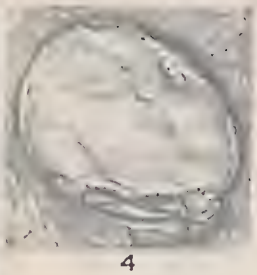

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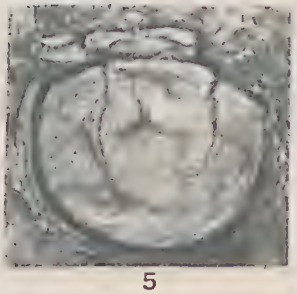

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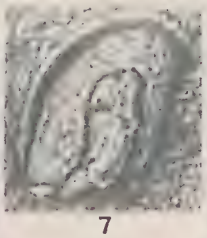

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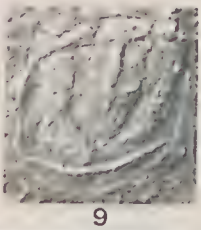

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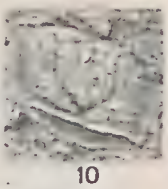

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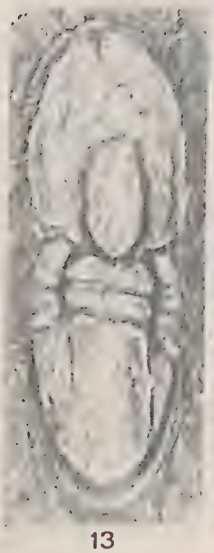

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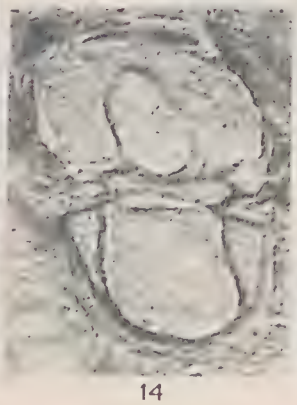

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PLATE 3

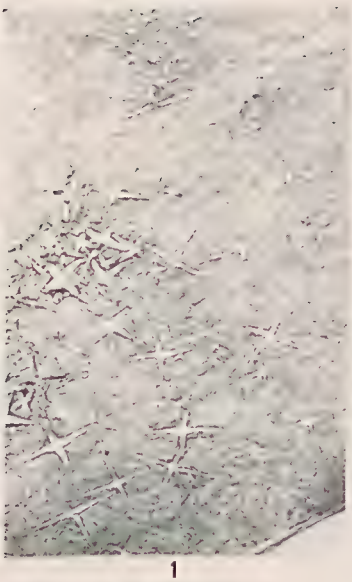
All figures are whitened with magnesium oxide.

Figs. 1, 2, 4. *Protospongia* sp. 1, UT 95158, accumulation of spicules, X3. 2, UT95158, close up of spicules in bottom left hand corner of Fig. 1, X6.5. 4, UT95158, side view of a cruciform stauract spicule which shows the umbrella-like appearance, X10.

Figs. 3, 5. Sponge spicules. 3, UT95159, tetraxon, X4. 5, UT95160, very long monaxon, X2.

Fig. 6. Bradoriid, UT95161, internal mould of (?) left value, X7.

Figs. 7-15 *Linnarssonia(?)* sp. 7, UT95162, internal mould of brachial valve, W form, X7.5. 8 UT95163, external mould of brachial valve, L form, X10. 9, UT95164, internal mould of brachial valve, W form, X9. 10, UT95165, internal mould of brachial valve (counterpart of Fig. 9), W form, X9. 11, UT95166, external mould of pedicle valve, W form, X8. 12, UT95167, external mould of pedicle valve, W form, X11. 13, UT95168, internal mould of pedicle valve, W form, X10. 14, UT95169, internal mould of pedicle valve (counterpart of UT95163, Fig. 9,)L form, X7.5. 15, UT95170, external mould of brachial valve, L form, X11.5.



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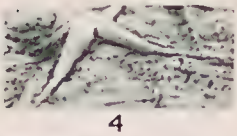

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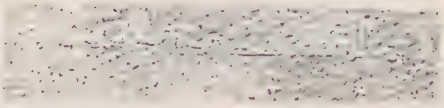

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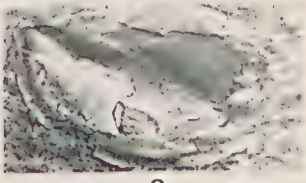

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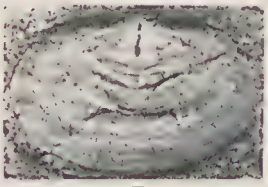

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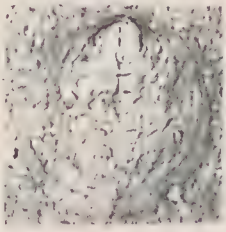

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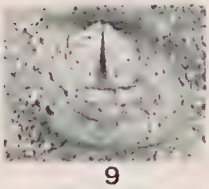

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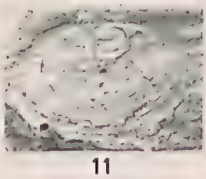

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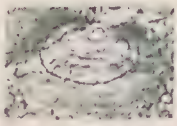

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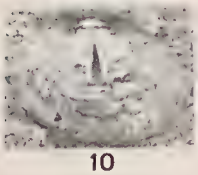

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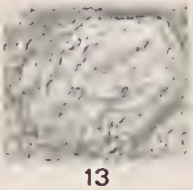

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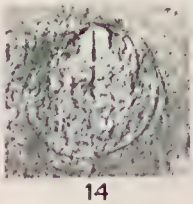

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OBSERVATIONS ON THE FOOD OF FRESHWATER FISH FROM THE COAL AND JORDAN RIVERS, TASMANIA

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(with five tables)

ABSTRACT

The Coal and the Jordan Rivers are two slow-flowing rivers in south-eastern Tasmania. Details are given of the stomach contents of brown trout *Salmo trutta* Linnaeus, English perch *Perca fluviatilis* Linnaeus, short-finned eels *Anguilla australis occidentalis* Schmidt and Tasmanian smelt *Retropinna tasmanica* McCulloch collected from the Coal River and of the stomach contents of brown trout, English perch, tench, short-finned eels, freshwater flathead *Pseudaphritis urvilli* (Cuvier and Valenciennes) and galaxiids *Galaxias maculatus* (Jenyns) collected from the Jordan River.

INTRODUCTION

The food of trout in Australia has been studied by McKeown (1934a, 1934b, 1936, 1937, 1955), Evans (1942), Butcher (1945, 1946), Wilson (1966) and Knott (1973). However, there are few published data on the food of native freshwater fish or even of non-salmonid introduced fish. Butcher (1945, 1946) examined the food of Macquarie perch, *Macquaria australasica* (Cuvier & Valenciennes), English perch, *Perca fluviatilis* Linnaeus, blackfish, *Gadopsis marmoratus* (Richardson) and *Galaxias maculatus* (Jenyns). McKeown (1934a) recorded the food of six Macquarie perch and brief non-quantitative descriptions of the food of some native and introduced freshwater fish of New South Wales are given by Lake (1959). Recently Pollard (1973) has provided a detailed account of the diet of land-locked *Galaxias maculatus* in Lake Modewarre, Victoria. In Tasmania the food of tench *Tinca tinca* (Linnaeus) has been studied by Weatherley (1962) and the food of a few specimens of the Tasmanian blackfish (*G. marmoratus*) has been recorded by Knott (1973).

There are no published accounts of the food of freshwater eels in Australia, despite the fact that eels, mainly short finned eels *Anguilla australis occidentalis* Schmidt, are common in coastal streams of south-eastern Australia and Tasmania and are considered by many anglers to damage the trout fisheries. Such a situation contrasts with the situation in New Zealand where there has been a number of studies of the food of freshwater eels mainly of the long finned eel *Anguilla dieffenbachi* Gray (e.g. Cairns 1942, Allen 1951, Burnet 1952, 1969, Hopkins 1965, 1970, Cadwallader 1975). Cairns (1942) and Burnet (1952) have shown that the diets of the long finned eel and the short finned eel are rather similar.

The present study is of a preliminary nature only and provides some data on the food of introduced brown trout *Salmo trutta* Linnaeus, English perch and tench and of the native short finned eel, freshwater flathead *Pseudaphritis urvilli* (Cuvier & Valenciennes), Tasmanian smelt *Retropinna tasmanica* McCulloch and *Galaxias maculatus*.

THE RIVERS OF INTEREST

The Coal River rises near Tunnack, flows westward for about 24 km to pass close to Lake Tiberias, then flows southward for about 56 km to enter the sea at Pittwater, near

Richmond.

The Jordan River is the outflow of Lake Tiberias and flows in a north-westerly direction to Jericho where it then flows in a southerly direction for about 80 km through Melton Mowbray, Broadmarsh and Brighton to enter the Derwent estuary near Bridgewater.

Data on the water chemistry of the five sampling sites on the Coal River where fish were collected are presented in table 1.

Data on the water chemistry of four localities on the Jordan River are given in table 2.

The Jordan River is both more alkaline and more saline than the Coal River. Both rivers may be regarded as "hard" with respect to calcium concentrations (Williams 1964).

MATERIALS AND METHODS

Fish were collected with an electro-fishing machine, which was constructed from a design by Dr R.H.K. Mann of the Freshwater Biological Association, U.K. (pers. comm.). The design of the control switch circuitry was modified from that in the original plan. Power was provided by a Honda E800 U generator and the A.C. current was rectified to either a 50 P.P.S. or 100 P.P.S. pulsed D.C. current.

The fish from the five sampling sites of table 1 were collected on 10 October and 24 October 1974. Two other fish samples from the Coal River were collected on 3 October 1975 and 26 March 1976. Both of these samples were collected about three km upstream from Campania near the Brown Mountain Road station of table 1. Fish were collected from the Jordan River on 2 April 1976 near the property of "Cliftonvale" where the road from Elderslie crosses the river.

After capture the fish were individually labelled with a metal tag and preserved in five per cent neutral formalin. Fish longer than about 100 mm were slit along the ventral surface to allow formalin to enter the body cavity. Stomachs were later removed from the fish and the stomach contents identified and recorded using the numerical method (Windell 1971).

RESULTS

Details of the stomach contents of the fish collected in the Coal River on the three separate occasions, October 1974, October 1975 and March 1976, are given in table 3. At the times of sampling in October 1974 and March 1976 the river was clear and at the normal low summer level, while in October 1975 the Coal River was turbid and fast flowing after a heavy spate.

Although the collection dates differed and the conditions of the river at the times of the three collections differed, to give an overall indication of the diets of the various fish species collected from the Coal River, the data of the three collections are combined in table 4.

The porportion of empty stomachs of each fish species captured from the Coal River varied considerably. The incidence of empty stomachs was low in trout, perch and smelt whereas in tench and eels the incidence was much higher.

In the Coal River, amphipods (*Austrochiltonia australis* (Sayce) and *Paracalliope fluviatilis* (Thomson)) formed the main part of the diets of the three most abundant fish, namely trout, eels and perch. Trichopteran larvae, mostly of the family Leptoceridae, constituted an important part of the diet of trout and eels, while Ephemeroptera were prominent in the diets of perch and eels. Their habit of feeding in the still parts of the river is reflected in the diet of tench, with gastropods and ostracods, both found in still, weedy stretches of the river, being important in the diet. Although only a few smelt were collected, the data suggest that chironomid larvae are an important food for this species.

Details of the stomach contents of fish collected from the Jordan River are given in table 5. As in the Coal River samples, eels and tench from the Jordan River had a relatively high incidence of empty stomachs compared with fish such as trout and perch.

There were some notable differences between the food of fish from the Jordan and

Coal Rivers. In the Jordan River aquatic dipteran larvae, mostly chironomids, are important in the diets of trout, eels and galaxiids, although trichopteran larvae form an important part of the diet of trout, eels and tench in both rivers.

DISCUSSION

In the following discussion the conclusions can only be of a tentative nature since the numbers of fish examined, especially of *Retropinna tasmanica*, *Pseudaphritis urvilli* and *Galaxias maculatus*, were relatively low. All fish were collected in early- to mid-afternoon. The tench and eels were notable for the relatively high proportion of fish with empty stomachs which may be due to nocturnal feeding habits. In New Zealand streams, eels have been reported to be more active and to feed at night (Cairns 1942, Cadwallader 1975) and Burnet (1952) also suggested that eels, especially large eels, are spasmodic feeders. Tench may also be largely nocturnal feeders since Weatherley (1962) observed that at night tench schools disperse and individuals swim "in apparent independence of each other". This activity may be related to nocturnal feeding.

In both rivers the basic food of trout consisted of trichopteran larvae (especially the cased eruciform larvae), decapod shrimps (*Paratya tasmaniensis* Riek) and amphipods (*Austrochiltonia australis* and *Paracalliope fluviatilis*). In the Jordan River aquatic dipteran larvae (mostly Chironomidae) were the dominant food.

Eels appear to be opportunistic in their choice of food. In the Coal River amphipods and trichopteran larvae were the most important food items, whereas in the Jordan River trichopteran larvae and dipteran larvae were the most important food items. In both rivers, eels closely resemble trout in the major food items eaten. Whether interspecific competition is severe between the two species is difficult to say from such a preliminary study. In both rivers, trout and eels occupy different habitats; trout prefer areas where there is some current, whereas eels prefer weedy areas and areas with sunken logs and plant debris. Thus, although they may eat similar food items, they may largely avoid competition by inhabiting and feeding in different habitats in the same river, as suggested by Burnet (1969).

Butcher (1945) and Lake (1959) in Victoria and New South Wales respectively, found that the food of perch *P. fluviatilis* consisted mainly of Crustacea and insect larvae, mainly Trichoptera. In the Coal River, amphipods were the major food of perch while in the Jordan River trichopteran larvae were the most important food. Perch were mainly caught in still and slow-flowing parts of the rivers, often in weedy stretches.

Tench were only collected in weedy, still sections of the rivers; a habitat they prefer (Weatherley 1962). In the Coal River gastropods were their major food, while trichopteran larvae were their major food in the Jordan River. The food of tench from the two rivers is similar to that recorded by Weatherley (1959).

The food of the small number of Tasmanian smelt examined consisted predominantly of dipteran (Chironomidae) and trichopteran larvae. Lake (1971) reported that mainland Australian species of *Retropinna* feed on algae and plankton. In New Zealand Allen (1951) found that the food of a small sample of the smelt *Retropinna osmeroides* Hector was dominated by chironomid larvae and pupae. He concluded that the food of smelt in rivers is similar to that of young trout and that food competition may occur between the two species.

Pseudaphritis urvilli was only collected in the Jordan River from sections with a gravel substrate and a moderate current flow. Although only a few fish were examined it appears that *P. urvilli* is carnivorous with trichopteran larvae, *Paratya tasmaniensis*, amphipods and gastropods forming the major part of the diet.

The sample of *Galaxias maculatus* from the Jordan River fed on Cladocera, aquatic dipteran larvae (mainly Chironomidae), Hymenoptera (Formicidae) and Amphipoda in decreasing order of importance. Pollard (1973) investigated the diet of a land-locked population of *G. maculatus* inhabiting Lake Modewarre in south-western Victoria and found that the diet consisted mainly of amphipods, chironomid larvae and small crustaceans (copepods, cladocerans, ostracods). Butcher (1946), Allen (1951) and McDowall (1968) found that the diet of stream-dwelling *G. maculatus* was dominated by dipterans (mainly chironomid larvae and pupae).

This preliminary study indicates that the different fish species in the Coal and Jordan Rivers share a common food resource. For example, in the Coal River amphipods form an important part of the diets of trout, perch and eels, whereas in the Jordan River trichopteran larvae (eruciform) form an important part of the diets of trout, perch, eels, tench and freshwater flathead. It is conceivable that interspecific competition for food is occurring in the rivers, for example between trout and smelt, perch and trout.

ACKNOWLEDGEMENTS

We wish to thank the Freshwater Ecology (Zoology III) students of 1975 and 1976 for their hard work in collecting the fish and examining the stomach contents and Messrs R.B. Mawbey, R. Norris, K.H. Lim and R. Sloane and Dr R. Gaymer for invaluable assistance in the execution of the practical exercises.

We are grateful to the Inland Fisheries Commission, Hobart, for permission, to electro-fish in the Coal and Jordan Rivers. We would also like to thank Dr P. Cadwallader, Fisheries and Wildlife Division, Ministry for Conservation, Snobs Creek, Victoria, and Mr W. Fulton, Inland Fisheries Commission, Hobart, for very thorough and constructive criticism of a draft manuscript.

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TABLE 1

Results of chemical analyses of Coal River water in October 1974

Locality	A	B	pH	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	SO_4^-	Alkalinity mg/l
						µeq/l					
Baden	20	185	7.9	1,350	40	880	270	920	850	320	47.5
Brandy Bottom	34	247	8.6	1,430	50	1,900	430	1,400	1,110	310	67.5
Craigbourne Rd	46	270	8.5	1,520	51	1,900	510	1,610	1,230	230	85.0
Brown Mountain Road	58	306	8.6	1,570	54	1,880	530	1,780	1,280	270	100.0
Laburnum Park	67	298	8.0	1,630	49	1,380	530	1,720	1,310	270	100.0

A kilometres downstream from source

B K_{18} µ S $_{cm}$-1

TABLE 2

Results of the analyses of some chemical features of Jordan River water

Locality	Total dissolved solids p.p.m.	pH	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^+	HCO_3^-	Alkalinity p.p.m.
					µeq/l				
Lake Tiberias[1]	463.6	7.6	4350	1024	130	2166	7360	2160	
Jordan River[2] (Jericho)	744-1345	7.4-8.1	-	-	-	-	-	-	194-396.5
Jordan River[2] (Pontville)	644	8.0	-	-	-	-	-	-	222
Jordan River[2] (Brighton)	622-1072	7.8-8.0	-	-	-	-	-	-	85.4-322.0

(1) Buckney and Tyler (1973)

(2) Williams (1964)

TABLE 3

Stomach contents of fish collected from the Coal River in October 1974, October 1975 and March 1976

Species of fish		*Salmo trutta*			*Anguilla australis*			*Perca fluviatilis*			*Tinca tinca*			*Retropinna tasmanica*
Date	Food item	October 1974 n = 20; e = ?	October 1975 n = 6; e = 0	March 1976 n = 5; e = 0	October 1974 n = 5; e = ?	October 1975 n = 13; e = 9	March 1976 n = 50; e = 21	October 1974 n = 7; e = ?	October 1975 n = 13; e = 4	March 1976 n = 6; e = 1	October 1974 n = 6; e = ?	October 1975 n = 18; e = 15	March 1976 n = 1; e = 1	October 1974 n = 6; e = ?
Annelida:	Oligochaeta (aquatic)	53	-	-	41	-	-	-	-	-	2	-	-	-
	Oligochaeta (terrestrial)	-	1	-	-	4	-	-	1	-	-	-	-	-
Crustacea:	Cladocera	-	-	-	10	-	-	-	-	-	-	-	-	-
	Ostracoda	-	-	-	-	-	3	-	-	-	156	-	-	-
	Amphipoda	672	20	258	92	33	113	850	215	291	8	14	-	7
	Isopoda (Phreatoicidea)	5	-	-	-	-	7	-	-	-	-	-	-	-
	Decapoda *(Paratya tasmaniensis)*	533	1	10	-	3	10	7	59	17	-	-	-	-
Insecta:	Ephemeroptera (nymphs)	4	-	-	46	-	3	214	12	-	22	-	-	-
	Plecoptera (nymphs)	80	-	-	22	1	-	29	2	-	3	-	-	-
	Odonata: Zygoptera (nymphs)	-	2	-	-	-	1	1	-	3	8	-	-	-
	Anisoptera (nymphs)	7	2	-	4	-	-	-	-	-	3	-	-	-
	Dermaptera	-	2	-	-	-	-	-	-	-	-	-	-	-
	Orthoptera	-	-	1	-	-	1	-	-	-	-	-	-	-
	Hemiptera (aquatic)	55	5	5	1	-	-	1	9	4	4	-	-	1
	Coleoptera (aquatic) larvae	26	-	-	1	-	-	1	-	-	9	-	-	5
	Coleoptera (terrestrial) adults	-	1	-	-	-	-	-	-	-	-	-	-	-
	Coleoptera (aquatic) adults	-	4	1	1	-	-	-	-	-	-	-	-	-
	Lepidoptera (aquatic) larvae	-	-	-	-	-	5	-	-	-	-	-	-	-
	Trichoptera larvae	500	321	-	58	-	3	7	3	5	129	2	-	20
	Hymenoptera, Formicidae	2	-	-	-	-	-	1	-	-	-	-	-	-
	Diptera (aquatic) larvae	15	2	6	18	-	11	52	5	3	26	-	-	23
	Diptera (adults)	25	-	-	-	-	-	-	-	-	-	-	-	6
Arachnida:	Hydracarina	2	-	-	2	-	-	-	-	-	-	-	-	-
Mollusca::	Bivalvia	-	-	-	-	-	1	-	-	-	-	-	-	-
Chordata :	Anura	2	-	-	-	-	-	-	-		-	-	-	-
Total number of food items:		2,273	363	282	299	41	162	1,164	306	323	870	16	-	62

n = number of fish examined e = number of fish with empty stomachs

TABLE 4

Summary of stomach contents of fish captured from Coal River in October 1974, October 1975 & March 1976

		Salmo trutta % n = 30	*Anguilla australia* % n = 68	*Perca fluviatilis* % n = 36	*Tinca tinca* % n = 25	*Retropinna tasmanica* % n = 6
Annelida:	Oligochaeta (aquatic)	1.82	8.17	-	0.23	-
	Oligochaeta (terrestrial)	.03	.80	.05	-	-
Crustacea:	Cladocera	-	1.99	-	-	-
	Ostracoda	-	.60	-	17.61	-
	Amphipoda	32.55	47.41	75.62	2.48	11.29
	Isopoda (Phreatoicidea)	.17	1.39	-	-	-
	Decapoda *(Paratya tasmaniensis)*	18.64	2.59	4.63	-	-
Insecta:	Ephemeroptera (nymphs)	.14	9.76	12.60	2.48	-
	Plecoptera (nymphs)	2.74	4.58	1.73	.33	-
	Odonata:					
	Zygoptera (nymphs)	.10	.40	.22	.90	-
	Anisoptera (nymphs)	.31	.80	-	.34	-
	Dermaptera	.06	-	-	-	-
	Orthoptera	.03	.20	-	-	-
	Hemiptera (aquatic)	2.23	.20	.78	.45	1.61
	Coleoptera (aquatic) larvae	.89	.20	.05	1.02	8.06
	Coleoptera (terrestrial) adults	.03	-	-	-	-
	Coleoptera (aquatic) adults	.17	.20	-	-	-
	Lepidoptera (aquatic) larvae	-	1.00	-	-	-
	Trichoptera larvae	28.14	12.15	.84	14.79	32.26
	Hymenoptera, Formicidae	.06	-	.05	-	-
	Diptera (aquatic) larvae	.79	5.78	3.35	2.93	37.09
	Diptera (adults)	.86	-	-	-	9.67
Arachnida:	Hydracarina	.06	.40	-	-	-
Mollusca:	Bivalvia	-	.20	-	-	-
	Gastropoda	10.07	1.00	.05	56.43	-
Amphibia:	Anura	.06	-	-	-	-

% = percentage of total number of food items

n = number of fish examined

TABLE 5

Details of the stomach contents of fish collected from the Jordan River on 2 April 1976

	Salmo Strutta n = 58 e = 9		*Anguilla australis* n = 91 e = 59		*Perca fluviatilis* n = 22 e = 5		*Tinca tinca* n = 27 e = 17		*Pseudaphritis urvilli* n = 8 e = 4		*Galaxias maculatus* n = 8 e = 1	
		%		%		%		%		%		%
Annelida: Oligochaeta (aquatic)	1	.22	-	-	-	-	-	-	-	-	-	-
Crustacea:												
Cladocera	2	.43	3	3.37			-	-	-		10	45.45
Ostracoda	-	-	-	-	3	4.28	-	-	-	-	1	4.54
Amphipoda	72	15.65	10	11.23	3	4.28	-	-	7	19.44	2	9.09
Isopoda (Phreatoicidea)	1	.22	1	1.23	2	2.85	-	-	-	-	-	-
Decapoda *(Paratya tasmaniensis)*	36	7.82	11	12.36	13	18.57	-	-	12	33.33	-	-
Insecta: Thysanura	9	1.95	1	1.23	3	4.28	-	-	-	-	-	-
Ephemeroptera (nymphs)	4	.87	-	-	-	-	-	-	1	2.77	-	-
Hemiptera (aquatic)	10	2.17	4	4.49	7	10.00						
Hemiptera (terrestrial)	1	.22	-	-	-	-	-	-	-	-	-	-
Coleoptera larvae (aquatic)	-	-	6	6.74	-	-	1	2.08	-	-	-	-
Coleoptera adults (aquatic)	1	.87	-	-	-	-	-	-	-	-	1	4.54
Coleoptera adults (terrestrial)	3	.65	-	-	-	-	-	-	-	-	-	-
Trichoptera larvae (eruciform)	59	12.83	21	23.59	38	54.29	44	91.66	12	33.33	1	4.54
Trichoptera larvae (campoderiform)	44	9.57	7	7.87	-	-	-	-	2	5.55	-	-
Trichoptera adults	4	.87	-	-	-	-	-	-	-	-	-	-
Hymenoptera Formicidae	14	3.04	-	-	1	1.43	3	6.25	-	-	2	9.09
Diptera larvae (aquatic)	169	36.74	12	13.48	-	-	-	-	-	-	3	13.64
Diptera larvae (terrestrial)	4	.87	12	13.48	-	-	-	-	-	-	-	-
Diptera adults	13	2.83	-	-	-	-	-	-	-	-	1	4.54
Arachnida: Araneae	1	.22	-	-	-	-	-	-	-	-	-	-
Mollusca: Gastropoda	9	1.95	1	1.23	-	-	-	-	2	5.55	-	-
Total number of food items:	460		89		70		48		36		22	

n = number of fish examined e = number of fish with empty stomachs % = percentage of total number of food items

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TASMANIAN TERTIARY FORAMINIFERIDA

PART 2, chiefly Spirillinacea to Glabratellidae

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(with three text-figures and five plates)

ABSTRACT

In this paper 77 foraminiferal taxa are recorded from the Late Oligocene to Early Miocene marine sediments of northern and northwestern Tasmania. They are recorded following the latest classification proposed by Loeblich and Tappan (1974). All known Tasmanian Tertiary species of the Superfamilies Robertinacea, Spirillinacea and Buliminacea are recorded. Most of the Superfamily Discorbacea is also recorded. Three species which could have been documented in Part 1 of this series are also listed. Of the taxa recorded, 53 are identified as previously described species or as similar to previously described species, 22 are left in open nomenclature and *Epistominella shauni* and *Angulodiscorbis ludbrookae* are described as new. Most species are figured with scanning electron microscope photographs.

INTRODUCTION

This paper is the second of a three- or four-part series on Tasmanian Tertiary foraminifera and follows Part 1 which was published in Vol. 108 of this journal (Quilty 1974). Other introductory comments are common to each paper. Quilty (1972) described the biostratigraphy of the source areas for the material described here and this paper should be read in conjunction with Quilty (1972).

Since Part 1 appeared, a sample of friable yellowish calcarenite has been collected at Ann Bay, Marrawah (Rock sample catalogued as UTGD 84561) and its content is included in the text here. It also contains some species of Superfamily Lituolacea which should be included in Part 1. They are: *Bdelloidina aggregata* Carter (v), *Textularia* sp. indet. (v), *Gaudryina convexa* (Karrer) (v). The locality of the new sample was shown by Quilty (1972, p.36, fig. 9) where outcrops of Tertiary marine rocks are shown in the southeastern corner of Ann Bay.

In addition to the new Marrawah material, further species have been recovered from Cape Barren Island and are recorded here for the first time. The locality was noted by Quilty (1972, p.28).

Two corrections to Part 1 may be noted here - (1) the accession number of *Guttulina regina* is 84224 not 84244, (2) the accession number for *Sigmoidella elegantissima* is 84231 not 87231.

CLASSIFICATION

Since Part 1 of this series was published the classification of the Foraminiferida proposed by Loeblich and Tappan (1964a, b) has been considerably modified and improved by Loeblich and Tappan (1974). The new scheme is followed here. The main improvement involves genera in the Superfamilies Discorbacea and Orbitoidacea and depends on the recognition that the lamellar character of the walls cannot be used for distinction at Superfamily level. The Orbitoidacea is much restricted, and now incorporates only the complex "orbitoid" genera. Morphologically simpler forms originally included in the Orbitoidacea have been transferred to the Discorbacea.

Superfamily LITUOLACEA
Family ATAXOPHRAGMIIDAE

Genus *VALVULINA* d'Orbigny, 1826

Valvulina sp.
(Pl.1, fig. 1)

Occurrence - Cape Barren Island (84554).
Age - Early Miocene, N8.

Superfamily ROTALIACEA
Family NODOSARIIDAE

Genus *LENTICULINA* Lamarck, 1804

Lenticulina rotulata Lamarck, 1804
(Pl.1, figs. 2, 3)

Lenticulites rotulata Lamarck, 1804, *Ann. Mus. natn. Hist. nat. Paris*, 5, 188.
Lenticulites rotulata Lamarck, 1806, *ibid.*, 8, pl. 62, fig. 11.
Occurrence - Cape Barren Island (84554).
Type locality and stratigraphic level - France, Late Cretaceous.
Age - Early Miocene, N8.

Genus *PLANULARIA* Defrance, 1826

Planularia sp.
(Pl. 1, fig.4)

Occurrence - Ann Bay, Marrawah (84561).
Age - Early Miocene, N4/5.

Superfamily ROBERTINACEA
Family CERATOBULIMINIDAE

Genus *CEROBERTINA* Finlay, 1939

Cerobertina bartrumi Finlay, 1939
(pl.1, figs. 5,6).

Cerobertina bartrumi Finlay, 1939, *Trans. R. Soc. N.Z.*, 69 (1), 118, pl. 2, figs. 2-3.
Cerobertina bartrumi; Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 113, pl.11, figs.214-216.
Type locality and stratigraphic level - Pakaurangi Point, New Zealand; Early Miocene.
Remarks
Only one broken specimen was recovered from Brittons Swamp (84480 (v)).
Age - Early Miocene, N8.

Genus *LAMARCKINA* Berthelin, 1881

Lamarckina glencoensis Chapman and Crespin, 1930
(Pl. 1, figs. 7, 8)

Lamarckina glencoensis Chapman and Crespin, 1930, *Proc. R. Soc. Vict.* n.s., 43, 99 pl. 5, figs. 11, 12.
Lamarckina glencoensis; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.
Lamarckina glencoensis; Crespin, 1950, *Contr. Cushman Lab. foramin. Res.*, 1, pl. 10, figs. 13a, b.
Lamarckina glencoensis; Raggatt and Crespin, 1955, *Proc. R. Soc. Vict.* n.s., 67, pl. 7, figs. 13a, b.
Lamarckina glencoensis; Carter, 1958, *Bull. geol. Surv. Vict.*, 55, 67, pl. 10, figs. 110-112.
Type locality and stratigraphic level - Victoria, No. 3 Bore, Parish of Glencoe at 30 m; Late Oligocene.

Remarks

This species is found at both Fossil Bluff and Cape Grim. In the Cape Grim samples, the dorsal pustules become smaller and less numerous as the rocks become younger, until in the highest sample, the specimens are completely "bald". The Fossil Bluff and lower Cape Grim specimens are more typical.

Occurrence - (a) Fossil Bluff - Freestone Cove Sandstone, 84010b (v), Fossil Bluff Sandstone, 84014 (r),
(b) Cape Grim - Cape Grim Beds, 84008 (r), 84007 (q), 84006 (v), 84002 (v), 84001 (v).

Age - Early Miocene, N4/5.

Family EPISTOMINIDAE

Genus *EPISTOMINA* Terquem, 1883

Epistomina elegans (d'Orbigny), 1826
(Pl. 1, figs. 9,10)

Rotalia (Turbinuline) elegans d'Orbigny, 1826, *Annls Sci. nat.* ser. 1, 7, 76.
Rotalia (Turbinuline) elegans (d'Orbigny); Parker, Jones and Brady, 1871. *Ann. Mag. nat. Hist.* ser. 4, 8, pl. 12, fig. 142.
Pulvinulina elegans (d'Orbigny); Chapman, 1910, *Proc. R. Soc. Vict.* n.s., 22, 288.
Pulvinulina elegans; Heron-Allen and Earland, 1924, *J. R. Microsc. Soc.* (1924), 180.
Epistomina elegans (d'Orbigny); Chapman, Parr and Collins, 1934, *J. Linn. Soc.*, 38 (262), 567, pl. 9, figs. 22a-c.
Epistomina elegans; Howchin and Parr, 1938, *Trans. R. Soc. S. Aust.*, 62, 305.
Type locality and stratigraphic level - Coroncina, Italy, "fossil".
Occurrence - Cape Grim - Cape Grim Beds, 84008 (v), 84006 (v), 84005 (r).
Age - Early Miocene, N4/5.

Superfamily and Family Uncertain

Genus *MISSISSIPPINA* Howe, 1930

Mississippina concentrica (Parker and Jones), 1864
(Pl. 1, figs. 11, 12)

Pulvinulina concentrica Parker and Jones, in Brady, 1864, *Trans. Linn. Soc.*, 24, 470, pl. 48, fig. 14.
Pulvinulina concentrica; Chapman, 1910, *Proc. R. Soc. Vict.* n.s., 22, 287.
Pulvinulina concentrica; Heron-Allen and Earland, 1924, *J. R. microsc. Soc.* (1924), 179.
Eponides concentricus (Parker and Jones); Chapman, Parr and Collins, 1934, *J. Linn. Soc.*, 38 (262), 565, pl. 9, figs. 17a-c.
Eponides concentricus; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 79.
Stomatorbina concentrica (Parker and Jones); Carter, 1958, *Bull. geol. Surv. Vict.*, 55, 40, pl. 4, figs. 37-39; pl. 7, fig. 75.
Stomatorbina concentrica; Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 74.
Mississippina concentrica (Parker and Jones); Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 78.
Type locality and stratigraphic level - Atlantic or Mediterranean Sea, Recent.

Remarks

One of the results to come from the study of this species, is an understanding of the possible structure of the ventral peripheral 'band' on each chamber of the species. A study of sections through this structure shows that the primary lamellae of the wall pass through the structure without interruption, indicating that it is part of the primary wall. Central ventral parts of the test are strongly thickened by many lamellae as is the entire dorsal surface, (excluding dorsal peripheral bands), peripheral keel and sutures.

Many of the conclusions reached here regarding the composition and structure of

the wall support those of McGowran (1966) who had much better material.

The position of the genus *Mississippina* in Loeblich and Tappan's (1974) classification is not clear. McGowran (1966) and the present study have shown that it cannot be placed in the Robertinacea as they envisage it. The wall has both granular and radial calcite elements and thus does not allow a ready fit into any of Loeblich and Tappan's Family or Superfamily categories. Perhaps a better position is as part of the Discorbacea, but its exact allocation is an interesting problem. It is certainly excluded by definition from any existing family. To accommodate it, the Discorbacea would need a proviso added that some members may contain primary monolamellid granular walls with secondary radial laminated calcite. Then a family would need to be erected to contain such forms as *Mississippina*, *Schlosserina* and possibly some other closely related forms.

Occurrence- (a) Mussel Roe Bay - 84483 (r), 84481 (r), 84482 (r),
(b) Fossil Bluff - Fossil Bluff Sandstone, 84024 (v),
(c) King Island - 84084 (v), 84086 (r), 84475 (q), 84476 (r),
(d) Daisy Creek - 84478 (r).
(e) Cape Grim - Cape Grim Beds, 84008 (r), 84007 (r), 84005 (r), 84002 (v), 84001 (v),
(f) Mt Cameron West - 84120 (v),
(g) Preservation Island - 84479 (r),
(h) Redpa - 84093 (v), 84095 (r), 84096 (v),
(i) Marrawah district - 84108 (r), 84110 (v), 84113 (r), 84114 (r), 84104 (r), 84101 (r), 84105 (r).

Age - Late Oligocene - Early Miocene, N3-N8.

Superfamily SPIRILLINACEA
Family SPIRILLINIDAE

Genus *SPIRILLINA* Ehrenberg, 1843

Spirillina decorata Brady, 1884
(Pl. 1, fig. 13)

Spirillina decorata Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 633, pl. 85, figs. 22-25.
Spirillina decorata; Howchin,1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 11.
Spirillina decorata; Carter,1958, *Bull. geol. Surv. Vict.*, 55, 33, pl. 3, figs. 22, 23.
Type locality and stratigraphic level - Atlantic Ocean, Recent.
Occurrence - Brittons Swamp - 84480 (v).
Age - Early Miocene, N8.

Spirillina inaequalis Brady, 1879
(Pl. 1, figs. 14, 15)

Spirillina inaequalis Brady, 1879, *Q. J. microsc. Sci.*, n.s. 19, 278, pl. 8, fig. 25.
Spirillina inaequalis; Brady,1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 631, pl. 85, figs. 8-11.
Spirillina inaequalis; Howchin,1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 11.
?Spirillina cf *inaequalis*; Chapman,1910, *Proc. R. Soc. Vict.*, n.s. 22, 282.
Spirillina inaequalis; Heron-Allen and Earland, 1924, *J.R. microsc. Soc.* (1924), pt. 2, 167.
Spirillina inaequalis; Chapman, Parr and Collins, 1934, *J. Linn. Soc.*, 38, 559, pl. 8, figs. 4a-c.
Spirillina inaequalis; Crespin,1943, *Palaeont. Bull.*, Canberra, 4, 83.
Type locality and stratigraphic level - Type locality not designated, South Atlantic or Pacific Oceans, Recent.

Remarks

Several species of *Spirillina* seem to be present in the samples studied. However, many specimens are poorly preserved and only three species can be identified.

Spirillina inaequalis is the largest species. It is markedly asymmetrical, one surface a low dome, with whorls clearly visible, the other concave and often smooth, with flush, indistinct sutures. The margin is more or less plane, sometimes concave, with the diameter on the domed side greater than that on the concave side.

The species figured and described by Brady (1879) differs from the specimens studied in that his species may have some obvious ornamentation on the domed side of the test but is otherwise similar.

Occurrence - (a) Fossil Bluff - Freestone Cove Sandstone, 84010b (r),
(b) King Island - 84084 (v), 84086 (r),
(c) Cape Grim - Cape Grim Beds, 84006 (r), 84005 (v), 84003 (q), 84002 (r), 84001 (r),
(d) Brittons Swamp - 84480 (v).

Age - Early Miocene, N4-N8.

Spirillina unilatera Chapman, 1902
(Pl. 1, fig. 16)

Spirillina decorata Brady var. *unilatera* Chapman, 1902, *J. Linn. Soc.*, 28, 410.
Spirillina unilatera; Carter, 1958, *Bull. geol. Surv. Vict.*, 55, 38, 39, pl. 4, figs. 26-29.

Type locality and stratigraphic level - near Funafuti Atoll, Recent.

Remarks

This form differs from *S. decorata* only in having surface pattern restricted to one side.

Occurrence - (a) Fossil Bluff - Fossil Bluff Sandstone, 84012 (r), 84013 (v),
(b) Cape Grim - Cape Grim Beds, 84008 (r),
(c) Brittons Swamp - 84480 (v).

Age - Early Miocene, N4-N8.

Spirillina spp. indet.

Remarks

Several specimens, which are unidentifiable, were recovered. They are poor glauconitic internal moulds or are marred by secondary recrystallization.

Occurrence - (a) Fossil Bluff - Fossil Bluff Sandstone, 84024 (v),
(b) Cape Grim - Cape Grim Beds, 84007 (r),
(c) Mt. Cameron West - 84118 (r), 84121 (v), 84120 (r),
(d) Marrawah district - 84092 (v), 84561 (r).

Age - Early Miocene.

Genus PATELLINA Williamson, 1858

Patellina corrugata Williamson, 1858
(Pl.1, fig.17)

Patellina corrugata Williamson, 1858, *Ray Soc. Publs* (1858), 46, pl. 3, figs. 86-89.
Patellina corrugata; Heron-Allen and Earland, 1924, *J. R. microsc. Soc.* (1924), pt. 2, 167.
Patellina corrugata; Chapman, Parr and Collins, 1934, *J. Linn. Soc.*, 38, 560, pl. 8, figs. 6a, b.
Patellina corrugata; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 82.
Patellina corrugata; Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34, 97, pl. 13, fig. 250.
Patellina sp., Hornibrook, 1961, *ibid.* fig. 251.

Type locality and stratigraphic level - North Atlantic, Recent.

Remarks

The specimens recovered show a range from the form usually figured to one with a very highly pointed dorsal surface. Included in this species are specimens probably the same as *Patellina* sp. (Hornibrook, 1961).

Occurrence - (a) Mussel Roe Bay - 84482 (v),

(b) Fossil Bluff - lower Fossil Bluff Sandstone, 84011 (v), 84012 (v), 84013 (v),
(c) Cape Grim - Cape Grim Beds, 84008 (r), 84006 (v),
(d) Mt. Cameron West - 84118 (r).

Age - Early Miocene, N4/5.

Superfamily BULIMINACEA
Family TURRILINIDAE

Genus BULIMINELLA Cushman, 1911

Buliminella sp. cf. *B. gracilis* Collins, 1953
(Pl. 1, fig. 18)

Type locality and stratigraphic level (*B. gracilis*), Great Barrier Reef, Australia, Recent.

Remarks

The figured specimen differs from *B. gracilis* only in the lack of surface ridges in the later part of the test. The similarities are so strong that it seems almost certain that the form recorded here is a predecessor to *B. gracilis*.

Occurrence - (a) Mussel Roe Bay - 84481 (v).
(b) Fossil Bluff - Freestone Cove Sandstone 84010a (r), 84010b (v); Fossil Bluff Sandstone, 84011 (v).

Age - Early Miocene, N4/5.

Buliminella elegantissima (d'Orbigny), 1839
(Pl. 1, fig. 19)

Bulimina elegantissima d'Orbigny, 1839, VOYAGE DANS L'AMERIQUE MERIDIONALE: FORAMINIFERES (V. Levrault: Strasborg), 5, 51, pl. 7, figs. 13, 14.
Bulimina elegantissima; Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 8.
Buliminella elegantissima (d'Orbigny); Cushman, 1919, *Proc. U.S. natn. Mus.*, 56, 606.
Buliminella elegantissima; Crespin, 1943, *Palaeont. Bull.*, Canberra 4, 77.

Type locality and stratigraphic level - Payta, Peru, Recent.

Remarks

Most species of *Buliminella* in the Tasmanian samples are so closely associated, mainly in the Fossil Bluff samples, that it seems probable that all are varieties of one biological species, and a very variable species at that. All species do seem to intergrade and putting a distinct boundary between for example, *B. elegantissima* and *B. madagascariensis* is very difficult. To help underline this difficulty, one can point to the change from one species name to another of *B. e.* var. *apiculata* to *B. m.* var. *spicata*, when the former name was found to be unavailable (Cushman and Parker, 1947, p.64).

The best specimens of all species of this genus recorded here, are from the lower parts of the Fossil Bluff section.

Occurrence - (a) Mussel Roe Bay - 84483 (v), 84481 (v), 84482 (r).
(b) Fossil Bluff - Freestone Cove Sandstone 84010a (r), 84010b (v),
(c) Marrawah district - 84561 (v), 84114 (v), 84105 (r).

Age - Late Oligocene - Early Miocene, N3-N8.

Buliminella madagascariensis (d'Orbigny), 1826
(Pl. 1, fig. 20)

Bulimina madagascariensis d'Orbigny, 1826, *Annls Sci. nat.* ser. 1, 7, 270, no.17.
Buliminella madagascariensis; Cushman and Parker, 1947, *Prof. Pap. U.S. geol. Surv.* 210-D, 68, pl. 17, figs. 15-17.

Type locality and stratigraphic level - Malagasy, Recent.

Remarks

A single poorly preserved, rather short, inflated specimen, similar to Cushman and Parker's (1947, pl. 17, fig. 17) was recovered from Marrawah (84107).

Age - Early Miocene, N8.

Buliminella spicata Cushman and Parker, 1942
(Pl. 1, fig. 21)

Bulimina elegantissima d'Orbigny var. *apiculata* Chapman, 1907, *J. Linn. Soc.*, 30, 31, pl. 4, fig. 77.
Bulimina elegantissima var. *apiculata*; Heron-Allen and Earland, 1924, *J. R. microsc. Soc.* (1924), (2), 143.
Buliminella madagascariensis (d'Orbigny) var. *spicata* Cushman and Parker (*in* Cushman, 1942) - *Bull. U.S. natn. Mus.*, 161 (3), 8, pl. 3, figs. 5, 6.
Buliminella spicata; Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 68.
Type locality and stratigraphic level - Grices Creek, Balcombe Bay, Victoria, Middle Miocene.
Occurrence - (a) Fossil Bluff - Freestone Cove Sandstone 84010a (r); Fossil Bluff Sandstone 84012 (r), 84013 (r),
(b) Marrawah district - 84092 (r).
Age - Early Miocene, N4.

Buliminella sp.
(Pl. 1, fig. 22)

Remarks
A single well-preserved small specimen from Mussel Roe Bay (84482 (v)) is markedly different from the other specimens of *Buliminella* in the sample. It is very similar to a specimen figured by Cushman and Parker (1947, pl. 16, fig. 19) as *B. choctawensis*.
Age - Early Miocene, N4.

Family SPHAEROIDINIDAE
Genus SPHAEROIDINA d'Orbigny, 1826

Sphaeroidina bulloides d'Orbigny, 1826
(pl. 1, figs. 23, 24)

Sphaeroidina bulloides d'Orbigny, 1826, *Annls Sci. nat.* ser. 1, 7, 267.
Sphaeroidina bulloides; Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 11.
Sphaeroidina bulloides; Heron-Allen and Earland, 1924, *J. Linn. Soc.*, (1924), (2), 166.
Sphaeroidina bulloides; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 83.
Sphaeroidina bulloides; Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 69.
Type locality and stratigraphic level - Rimini, Italy, Recent.
Occurrence - (a) Mussel Roe Bay - 84483 (v), 84481 (v),
(b) Fossil Bluff - Fossil Bluff Sandstone, 84015 (f), 84019 (r), 84025 (v), 84025b (v),
(c) Cape Grim - Cape Grim Beds, 84008 (v), 84006 (v), 84005 (v), 84001 (v),
(d) Mt. Cameron West - 84117 (r),
(e) Marrawah district - 84092 (r), 84106 (r).
Age - Late Oligocene - Early Miocene, N3-N8.

Family BOLIVINITIDAE

Genus BOLIVINA d'Orbigny, 1839
Subgenus BOLIVINA d'Orbigny, 1839

Bolivina (Bolivina) retiformis Cushman, 1936
(Pl. 1, fig. 25)

Bolivina scalprata Schwager var. *retiformis* Cushman, 1936, *Spec. Publs Cushman Lab.*, 6, 53, pl. 7, figs. 19a, b.
Bolivina scalprata Schwager var. *retiformis*; Cushman, 1937, *Spec. Publs Cushman Lab.*, 9, 84, pl. 9, figs. 35-37.
Type locality and stratigraphic level - Wadi Sudr, Egypt, Miocene.

Remarks

About six or seven specimens have been recovered, all of which are quite poorly preserved. Although not obvious on the figured specimen the reticulate pattern usually is visible and the species is almost certainly that recorded by Cushman (1937, p.84) from Torquay, Victoria. Another very similar species appears to be *B. aenariensis* (Costa).

Occurrence - (a) Mussel Roe Bay - 84481 (v),
(b) Mt. Cameron West - 84120 (v),
(c) Marrawah district - 84092 (r), 84561 (v), 84104 (v), 84101 (v).

Age - Early Miocene, N4-N8.

Bolivina (Bolivina) sp. C
(Pl. 1, fig. 26)

Remarks

A single specimen of an apparently undescribed species was found in sample 84002 from the Cape Grim Beds at Cape Grim. As it is only one specimen, it is not formally described. In most respects such as peripheral characters, general test outline and chamber arrangement, it is very similar to *B. alata* (Seguenza) (see Cushman, 1937, pl. 13, especially fig. 5). However it has a distinct difference in that the test has a clear raised irregular ridge on each side at the line of junction of the biserial parts of chambers. Each ridge is made of small lateral projections from each chamber roughly perpendicular to the plane of the test. Thus, in section, the test has a cruciform appearance, one axis of the cross being much longer than the other. The test wall is also more coarsely perforate than that of *B. alata*. I have seen a specimen of the same species separated by Mr. D.J. Taylor who has designated it *B.* sp. 15.

Age - Early Miocene, N4/5.

Subgenus BRIZALINA Costa, 1856

Bolivina (Brizalina) finlayi Hornibrook, 1961
(Pl. 1, fig. 27)

Bolivina finlayi Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 75, pl. 9, figs. 169-171.

Type locality and stratigraphic level - Target Gully shell bed, Oamaru, New Zealand, Early Miocene.

Remarks

This name is applied to a single specimen from Fossil Bluff (84024) which has very fine radiating striae on the lower half of its test. It is virtually only a striate form of *B. victoriana*.

Occurrence - Fossil Bluff - Fossil Bluff Sandstone, 84024 (v).

Age - Early Miocene, N4/5.

Bolivina (Brizalina) victoriana Cushman, 1936
(Pl. 2, fig. 1)

Bolivina victoriana Cushman, 1936, *Spec. Publs Cushman Lab.*, 6, 55, pl. 8, figs. 2a, b.
Bolivina victoriana; Cushman, 1937, *Spec. Publs Cushman Lab.*, 9, 104, pl. 12, fig. 15 (not *B. hebes* var. *victoriensis* Cushman, *ibid.* 83, pl. 9, fig. 30).
Bolivina victoriana; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 77.
Bolivina victoriana; Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 76.

Type locality and stratigraphic level - Torquay Bore, Victoria, Oligocene.

Remarks

Taylor (1965, 1966, 1967) has used a series of *Bolivina* lineages in subdividing the sequences found in the Bass Strait and Gippsland Basin bores. One of his series (including his *B.* sp. 12) probably lies within *B. victoriana*.

Typical members of this species are probably best developed in sediments now assigned to the Longfordian stage. Earlier forms (Mussel Roe Bay) and later (upper parts of the Marrawah section) seem to be a little more compressed than the typical

form and some later specimens have slightly elevated sutures.

For additional comments, see *B.* sp. A.

Occurrence - (a) Mussel Roe Bay - 84483 (v), 84481 (v),
(b) Fossil Bluff - Freestone Cove Sandstone, 84010a (v);
Fossil Bluff Sandstone, 84011 (v), 84016 (r), 84017 (r), 84019 (r), 84022 (v), 84025a (r), 84024 (r), 84025b (r),
(c) Cape Grim - Cape Grim Beds, 84008 (v), 84006 (r),
(d) Mt. Cameron West - 84121 (v), 84120 (v),
(e) Brittons Swamp - 84480 (v),
(f) Marrawah district - 84561 (v), 84108 (r), 84110 (v), 84111 (r), 84104 (v), 84105 (r), 84106 (q), 84107 (q).

Age - Late Oligocene - Early Miocene, N3-N8.

Bolivina (Brizalina) sp. A
(Pl. 2, fig. 2)

Remarks

Six specimens were recovered of a species which seems to be a derivative of *B. victoriana.* In the later parts of the test it is compressed with a carinate margin. In the earlier parts it is the same as *B. victoriana,* i.e. it has rounded margins and smooth chamber surface. The later half of the test is very similar to the species figured by Carter (1964, pl. 2, figs. 33, 34) as *B. alata* (Seguenza). It is possible that the three forms form an evolutionary series.

Occurrence - Marrawah district - 84113 (v), 84104 (r).

Age - Early Miocene, N8.

Bolivina (Brizalina) sp. B
(Pl. 2, fig. 3)

Remarks

A small species with a smooth surface, compressed test with rounded margin and seven to eight pairs of chambers was found in three Longfordian samples. It is represented by a single specimen in each. It may be a microspheric form of one of the other species recorded.

Occurrence - (a) Mussel Roe Bay - 84481 (v), 84482 (v),
(b) Fossil Bluff - Fossil Bluff Sandstone, 84017 (v).

Age - Early Miocene, N4/5.

Genus LATEROSTOMELLA de Klasz and Rérat, 1962

Laterostomella sp.
(Pl. 2, fig. 4)

Remarks

A single specimen from the Fossil Bluff Sandstone at Fossil Bluff (84013) is tentatively referred to this genus. It is very similar to *L. guembeliniformis* de Klasz and Rérat as figured by Loeblich and Tappan (1964a, p.C553, fig. 437). The present species has a relatively larger proloculus. Apertural details are not very clear but the aperture is not central in the apertural face, and the outer lip is "somewhat flaring", so the above generic designation is probably correct. It does not appear to have been described as a species of *Bolivina* and is probably a new species. It may bear some relationship to *Bolivina hebes* Macfadyen var. *victoriensis* Cushman.

Age - Early Miocene, N4/5.

Family BULIMINIDAE
Subfamily PAVONININAE

Genus REUSSELLA Galloway, 1933

Reussella ensiformis (Chapman), 1910
(Pl. 2, fig. 5)

Verneuilina ensiformis Chapman, 1910, *Proc. R. Soc. Vict.*, n.s. 22, 271, pl. 52, fig. 1.
Reussella ensiformis; Cushman, 1937, *Spec. Publs Cushman Lab.*, 7, 20.
Reussella ensiformis; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 83.
Reussella ensiformis; Cushman, 1945, *Contr. Cushman Lab. foramin. Res.*, 21, (2), 35, pl. 6, fig. 14.
Type locality and stratigraphic level - Filter Quarries, Batesford, Victoria, Middle Miocene.

Remarks

This species is identified by its elongate test which is, in large specimens, quite strongly tapering at the base but very weakly tapering later on. It is distinct from *R. spinulosa* (Reuss) in lacking spinose extremities on each chamber. It seems unlikely that this species is the same as that figured by Heron-Allen and Earland (1924, pl. 7, fig. 5, 6) as *Verneuilina ensiformis*, because Heron-Allen and Earland's figures seem to show a species with deeply re-entrant sides.

Occurrence - (a) Mussel Roe Bay - 84482 (r),
(b) Cape Grim - Cape Grim Beds, 84005 (r), 84002 (v),
(c) Preservation Island - 84479 (v),
(d) Redpa - 84094 (r),
(e) Marrawah district - 84107 (v).

Age - Early Miocene, N4-8.

Reussella n. sp.
(Pl. 2, fig. 6)

Description

Test free, triserial throughout, with markedly concave faces. Test tapering strongly, maximum width half to two thirds of length from the base. Margins of faces carinate but not spinose. Basal angle = 60°. Length/width ratio 1.3 to 1.5. Test of about eight to ten whorls, poor preservation making accurate assessment difficult. Chambers quite strongly recurved distally. Apertural details not discernible.

Remarks

Only three specimens were recovered. They are 0.55 x 0.37, 0.6 x 0.45, and 0.47 x 0.32 mm respectively. Preservation is quite poor and immersion in refractive index liquids helps little in elucidating details, so the species is not formally named.

It is possible that the species figured by Heron-Allen and Earland (1924, pl. 7, figs. 10, 11) as *Tritaxia pyramidata* Reuss, is actually this species. Their species appears uniserial, but the chamber details are difficult to evaluate in this species. The cross-section of the test, the chamber shape and recurvature of the chambers are all consistent with it being conspecific. Their figures show a slightly more elongate specimen, but this may well fall within the specific variation which is hardly definable from three specimens. Their own note on the species shows that their specimens have a hyaline wall contrasting quite noticeably with the type figures (Reuss, 1862, pl. 1, figs. 9a-c) of *T. pyramidata*.

Similar species include *R. recurvata* (Halkyard) which differs in having almost straight, radial chambers and maximum width near the apertural end. *R. eocena* (Cushman) is probably different in having a lower length/width ratio but again this could perhaps be within the specific variation. Of the described species, *R. eocena* seems the most similar.

Occurrence - Marrawah district - 84114 (v), 84105 (v).

Age - Early Miocene, N8.

Reussella spinulosa (Reuss), 1850
(Pl. 2, fig. 7)

Verneulina spinulosa Reuss, 1850, *Denkschr. Akad. Wiss., Wien*, 1, 374, pl. 47, fig. 12.
Reussella spinulosa (Reuss); Cushman, 1945, *Contr. Cushman Lab. foramin. Res.*, 21 (2), 33, pl. 6, figs. 8, 9.
Reussella spinulosa (Reuss); Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 83.
Type locality and stratigraphc level - Vienna Basin, Miocene.
Occurrence - (a) Fossil Bluff - lower Fossil Bluff Sandstone 84011 (v),
(b) Daisy Creek - 84478 (v),
(c) Cape Grim - Cape Grim Beds, 84008 (r), 84001 (v),
(d) Redpa - 84096 (v),
(e) Marrawah district - 84092 (v), 84561 (v), 84113 (v), 84101 (r), 84106 (r), 84107 (r).
Age - Early Miocene, N4-N8.

Genus TUBULOGENERINA Cushman, 1927

Tubulogenerina mooraboolensis Cushman, 1927
(Pl. 2, fig. 8)

Bigenerina conica Heron-Allen and Earland (Part), 1909, *J. R. microsc. Soc.* (1909), 329, pl. 16, figs. 2-6.
Bigenerina conica; Chapman, 1910, *Proc. R. Soc. Vict.*, n.s. 22, 271.
Bigenerina conica; Heron-Allen and Earland, 1924, *J. R. microsc. Soc.* (1924), 140.
Tubulogenerina mooraboolensis Cushman, 1927, *Contr. Cushman Lab. foramin. Res.*, 2 (4), 78.
Tubulogenerina mooraboolensis; Cushman, 1937, *Spec. Publs Cushman Lab.*, 9, 217, pl. 24, fig. 22.
Tubulogenerina mooraboolensis; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 84.
Tubulogenerina mooraboolensis; Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, 80.
Type locality and stratigraphic level - Filter Quarries, Batesford, Victoria, Middle Miocene.
Occurrence - (a) Fossil Bluff - lower Fossil Bluff Sandstone, 84013 (v),
(b) Brittons Swamp - 84480 (v).
Age - Early Miocene, N4-N8.

Buliminid *incertae sedis*
(Pl. 2, figs. 9, 10)

? Chrysalidina costata Heron-Allen and Earland, 1924, *J. R. microsc. Soc.* (1924), 139, pl. 8, figs. 12-14.

Remarks

From Mussel Roe Bay (84481 (v)) was recovered a single well preserved specimen of an apparently undescribed genus. The very small early chambers make analysis of the older part of the test difficult. The later chambers increase rapidly in size and the final chamber has a simple central aperture which is surrounded by very many small supplementary areal apertures. The general growth form is somewhat like that of a *Bulimina*, and very much like that of the species figured by Heron-Allen and Earland (*op. cit.*) as *Chrysalidina costata*. The species is not *Chrysalidina* as that genus is arenaceous.

The unusual final chamber is almost identical with several illustrations of the temporary final chamber associated with reproduction in *Tretomphalus bulloides*. The only difference is that *T. bulloides* does not have a central primary aperture.
Age - Early Miocene, N4/5.

Family UVIGERINIDAE
Genus ANGULOGERINA Cushman, 1927

Angulogerina australis (Heron-Allen and Earland), 1924
(Pl. 2, fig. 11)

Uvigerina canariensis var. *australis* Heron-Allen and Earland, 1924, *J. R. micros. Soc.* (1924), (2), 164, pl. 11, figs. 67-70.

Angulogerina australis (Heron-Allen and Earland); Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 67, pl. 9, fig. 157.

Type locality and stratigraphic level - "Filter Quarry", Moorabool River, Victoria, Miocene.

Occurrence - (a) Mussel Roe Bay - 84481 (v),
(b) Marrawah district - 84561 (v).

Age - Early Miocene N4/5.

Genus EUUVIGERINA Thalmann, 1952
Subgenus HOFKERUVA Vella, 1961

Rather than dismiss Vella's genus *Hofkeruva* outright, as Loeblich and Tappan (1964) have done, I prefer to regard his probably phylogenetically separate groups *Hofkeruva* and *Euuvigerina s.s.* as separate taxonomic entities. Whether these are genera or subgenera is a matter of personal taste and in the long run does not matter a great deal. They are here regarded as subgenera of *Euuvigerina*.

Euuvigerina (Hofkeruva) semiteres (Vella), 1961
(Pl. 2, fig. 12)

Hofkeruva (Tereuva) semiteres Vella, 1961, *Micropaleontology*, 7 (4), 475, pl. 1, figs. 13, 14.

Type locality and stratigraphic level - Mata River, North of Waikopiro Stream junction, New Zealand, Early or Middle Miocene.

Remarks

The species is represented by a few poorly preserved specimens. Ribs are present on early chambers but are rare or absent on the ultimate and penultimate chambers. The range in Tasmania begins earlier than in New Zealand but the termination is very similar.

Occurrence - Marrawah district - 84561 (v), 84110 (v), 84104 (v), 84106 (v).

Age - Early Miocene, N4-N8.

Euuvigerina (Hofkeruva) schwageri (Brady), 1884
(Pl. 2, fig. 14)

Uvigerina schwageri Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 575, pl. 74, figs. 8-10.

Remarks

The general growth habit of this species is very similar to that of *E. (H.) semiteres* (Vella) but has very strong ribs on the early chambers, in contrast to *E. semiteres* which has finer, sharper ribs. In this feature, there may be some link with *E. (H.) gargantua* (Vella). It is represented by a single specimen.

Occurrence - Marrawah district - 84561 (v).

Age - Early Miocene, N4/5.

Euuvigerina (Hofkeruva) euteres (Vella), 1961
(Pl. 2, fig. 15)

Hofkeruva (Tereuva) euteres Vella, 1961, *Micropaleontology*, 7, (4), 476, pl. 1, figs. 6, 7.

Remarks

A single, large (0.54 mm) specimen of a species with very inflated chambers was recovered from Marrawah (84105). The surface ornament is restricted to very weak longitudinal costae on the earlier one-third of the test. The rest is smooth. Of

those species described by Vella (1961) it seems identical to *E. euteres*, but appears to occur in older rocks in Tasmania than in New Zealand.
Age - Early Miocene, N8.

Euuvigerina (Hofkeruva) sp.
(Pl. 2, fig. 13)

Remarks
This species is unique among Tasmanian Oligo-Miocene forms in possessing short, discontinuous ribs which give the species a very characteristic appearance. The most similar species seems to be *Uvigerina bradyana* Fornasini, which has the same rib character, but the Tasmanian form seems a more robust form which has only ribs as surface pattern. *U. bradyana* also has short surface spines.
Occurrence - (a) Cape Grim - Cape Grim Beds, 84008 (v), 84006 (v),
(b) Marrawah district - 84561 (v).
Age - Early Miocene, N4/5.

Genus SIPHOGENERINA Schlumberger, 1882

Siphogenerina canariensis (d'Orbigny), 1839
(Pl. 2, fig. 16)

Uvigerina canariensis d'Orbigny, 1839, HISTOIRE NATURELLE DES ILES CANARIES; FORAMINIFERES (Bethany: Paris), 2 (2), 138, pl. 1, figs. 25-27.
Uvigerina canariensis; Brady, 1884, *"Challenger" Expedn. Scient. Results, Zool.*, 9, 573, pl. 74, figs. 1-3.
Uvigerina canariensis; Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 65, pl. 8, fig. 143.
?Neouvigerina cf *interrupta* (Brady); Vella, 1961, *Micropaleontology*, 7 (4), 471, pl. 2, fig. 7.
Type locality and stratigraphic level - Canary Islands, Recent.
Remarks
This name is applied here to what is (i) very probably the species which Hornibrook *(op. cit)* identified as *Uvigerina canariensis*, and (ii) very questionably to that figured by Vella *(op. cit)* as *Neouvigerina* cf. *interrupta*. It is possibly distinct from the latter in having an extremely finely hispid surface, not the finely nodose one mentioned by Vella. The figured specimen is uniserial in later chambers and is thus transferred to *Siphogenerina*. It is very similar to Brady's *(op. cit.)* figures.
Occurrence - (a) Fossil Bluff - Freestone Cove Sandstone, 84010a (v);
Fossil Bluff Sandstone, 84011 (r), 84019 (v), 84022 (v), 84025a (v), 84024 (r),
(b) Marrawah district - 84561 (v).
Age - Early Miocene N4/5.

Siphogenerina moorei (Vella), 1961
(Pl. 2, fig. 17)

Neouvigerina moorei Vella, 1961, *Micropaleontology*, 7 (4), 472, pl. 2, fig. 17.
Type locality and stratigraphic level - Mangarara Stream, New Zealand, Middle Miocene.
Remarks
As with many other uvigerinid species, the stratigraphic position is different from similar or identical New Zealand species.
Occurrence - Marrawah district 84561 (v).
Age - Early Miocene N4/5.

Genus TRIFARINA Cushman, 1923

Trifarina bradyi Cushman, 1923
(Pl. 2, fig. 18)

Trifarina bradyi Cushman, 1923, *Bull. U.S. natn. Mus.*, 104 (4), 99, pl. 22, figs. 3-9.
Rhabdogonium tricarinatum (d'Orbigny); Heron-Allen and Earland, 1924, *J. R. microsc.*

Soc. (1924), (2), 158.
Trifarina bradyi; Chapman and Parr, 1926, *J. Linn. Soc.*, 36, 386, pl. 20, fig. 52
Trifarina bradyi; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 84.
Trifarina bradyi; Ludbrook, 1961, *Bull. geol. Surv. S. Aust.*, 36, 20, 26, 34, 49, etc.
Trifarina bradyi; Reed, 1965, *Bull. Am. Paleont.*, 49, (220), 68.
Type locality and stratigraphic level - Atlantic Ocean; Recent.
Occurrence - (a) Mussel Roe Bay - 84481 (v), 84482 (r),
(b) Fossil Bluff - Freestone Cove Sandstone 84010a (r), 84010b (v);
Fossil Bluff Sandstone, 84025a (v), 84025b (v),
(c) Redpa - 84097 (v), 84093 (v), 84094 (r), 84096 (v),
(d) Brittons Swamp - 84480 (v),
(e) Marrawah district - 84092 (r), 84561 (f), 84107 (r).
Age - Early Miocene, N4-N8.

Superfamily DISCORBACEA
Family DISCORBIDAE
Subfamily DISCORBINAE

Genus BUCCELLA Andersen, 1952

Buccella frigida (Cushman), 1922
(Pl. 2, figs. 19, 20)
Rotalia karsteni Reuss, 1855, *Z. dt. geol. Ges.*, 7, (1), 273, pl. 9, fig. 6.
Pulvinulina frigida Cushman, 1922, *Contr. Canadian Biol.*, (1921), 9, 12, (144).
Bucella frigida (Cushman); Anderson, 1952, *J. Wash. Acad. Sci.*, 42 (5), 144, 147, tf. 4-6.
Type locality and stratigraphic level - Canadian Arctic, Recent.
Remarks
While the name *B. frigida* is used for these specimens, it is not quite clear to me that they can be separated from *B. karsteni*.
Occurrence - (a) Cape Grim - Cape Grim Beds, 84008 (r), 84006 (q), 84005 (r), 84001 (r),
(b) Marrawah district - 84561 (v).
Age - Early Miocene, N4/5.

Buccella lotella Hornibrook, 1961
(Pl. 2, figs. 21, 22)
Bucella lotella Hornibrook, 1961, *Palaeont. Bull.*, Wellington 34 (1), 110, pl. 15, figs. 314-316.
Type locality and stratigraphic level - Pukeuri Township, New Zealand, Early Miocene.
Remarks
Several specimens from Redpa and Marrawah are referred to this species. Preservation is generally poor, the specimens appearing hispid due to secondary recrystallization. However, on one specimen, apertural details seen are enough to establish the generic designation and on others, the chamber arrangement is clear enough to suggest that the species is *B. lotella*.
Occurrence - (a) Redpa - 84095 (v),
(b) Marrawah district - 84113 (q), 84114 (v).
Age - Early Miocene, N8.

Genus DISCORBINELLA Cushman and Martin, 1935

Discorbinella araucana (d'Orbigny), 1839
(Pl. 2, figs. 23-25)
Rosalina araucana d'Orbigny, 1839, VOYAGE DANS L'AMERIQUE MERIDIONALE: FORAMINIFERES (Levrault: Strasbourg), 5, (5), 44, pl. 6, figs. 16-18.
Discorbina araucana; Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 645, pl. 86, figs. 10,11.
Discorbina araucana; Howchin, 1889, *Trans. Proc. R. Soc. Aust.*, 12, 12.

Discopulvinulina (?) *araucana* (d'Orbigny); Barker, 1960, *Spec. Publs. Soc. Econ. Paleont. Miner.*, Tulsa 9, 178, pl. 86, figs. 10, 11.
Type locality and stratigraphic level - near Valparaiso, Chile, Recent.
Remarks
Barker *(op. cit.)* questions the possibility that this species is congeneric with *D. bertheloti* (d'Orbigny) but both species appear to fit well the diagnosis of *Discorbinella*. Following Loeblich and Tappan (1964a, p.C575), *Discorbinella* is preferred to *Discopulvinulina*.
Occurrence - (a) Mussel Roe Bay - 84483 (v), 84482 (r),
(b) Cape Grim - Cape Grim Beds, 84001 (v),
(c) Marrawah district - 84561 (r).
Age - Late Oligocene - Early Miocene, N3-N5.

Discorbinella bertheloti (d'Orbigny), 1839
(Pl. 2, figs. 26, 27; pl. 3, figs. 1, 2)

Rosalina bertheloti d'Orbigny (*in* Barker-Webb and Berthelot), 1839, HISTOIRE NATURELLES DES ILES CANARIES (Bethany: Paris), 2 (2), 135, pl. 1, figs. 28-30.
Discorbis bertheloti (d'Orbigny); Chapman, Parr and Collins, 1934, *J. Linn. Soc.*, 38, 561, pl. 9, figs. 13a-c.
Rosalina scopos Carter, 1958, *Bull. geol. Surv. Vict.*, 55, 41, pl. 4, figs. 34-36.
Discopulvinulina bertheloti (d'Orbigny); Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34, 106, pl. 14, fig. 286.
Rosalina bertheloti (d'Orbigny); Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 77.
Type locality and stratigraphic level - Canary Islands, Recent.
Remarks
This species is obviously the same one figured and described by Carter (1958, *op. cit.*). However, it is not so clear that it is the species described by Finlay (1940) as *Discorbis scopos*. That species has a more evolute dorsal surface and only about eight chambers in the final whorl, (counting the maximum number visible on the involute dorsal surface and nine or ten chambers (counted in the same way as *R. scopos*).

The species has a closer resemblance to Hornibrook's (1961, pl. 14, fig. 286) figure of *Discopulvinulina* (now *Discorbinella*) *bertheloti* (d'Orbigny), which may in turn have too many chambers per whorl to be d'Orbigny's *Rosalina bertheloti*, the latter possibly having only about seven or eight and a much more acute periphery.

Reed (1965, *op. cit.*) apparently noticed some of the above anomalies and referred the species to *R. bertheloti* d'Orbigny. If it does belong to *D. bertheloti*, that species has seven to ten chambers in the final whorl. A feature, apparently previously unrecorded in this species, noticeable on one specimen, is the occurrence of radial striae on the ventral surface, suggesting a closer relationship with the Glabratellidae than has previously been suggested. It may be that ventral radial striae are a more common feature in the Discorbacea than the literature indicates.
Occurrence - (a) Mussel Roe Bay - 84481 (v),
(b) Fossil Bluff - Freestone Cove Sandstone 84010b (r);
Fossil Bluf Sandstone, 84011 (r), 84012 (q), 84013 (q), 84015 (q), 84017 (r), 84019 (r), 84022 (r), 84023 (q), 84024 (r), 84025a (q), 84025b (q),
(c) Cape Grim - Cape Grim Beds, 84008 (v), 84006 (v),
(d) Mt. Cameron West - 84118 (r), 84121 (r), 84120 (r),
(e) Redpa - 84093 (v),
(f) Marrawah district - 84092 (r), 84111 (r), 84114 (v).
Age - Early Miocene, N4-N8.

Discorbinella sp. cf *D. bertheloti* (d'Orbigny), 1839
(Pl. 3, figs. 3, 4)

Remarks
In two samples from Mt. Cameron West (84120 (v), 84117 (r)) were found specimens of a species close to the species recorded above, but differing from it in having

eleven or twelve chambers per whorl and a more rounded periphery.
Age - Early Miocene, N4/5.

Genus DISCORBIS Lamarck, 1804

Discorbis balcombensis Chapman, Parr and Collins, 1934
(Pl. 3, figs. 5-8, 11-13)

Discorbis balcombensis Chapman, Parr and Collins, *J. Linn. Soc.*, 38 (262), 562, pl. 8, figs. 10a-c.
Discorbis finlayi Dorreen, 1948, *J. Paleont.*, 22, 293, pl. 38, figs. 12a-c.
Rotorbinella finlayi (Dorreen); Bermudez, 1952, *Boln Geol. Minist. Minas. Venez.*, 2, 75.
Discorbis balcombensis; Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 98, pl. 13, fig. 252.
Discorbis balcombensis; Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 77, pl. 3, figs. 64-66.
Discorbis finlayi; Loeblich and Tappan, 1964, *Treat. Invert. Paleont.* C2(2), C574.
Discorbis balcombensis; Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 69.
Type locality and stratigraphic level - Kackeraboite Creek, Port Phillip, Victoria, Miocene.

Remarks

This is a dominant species in the Cape Grim section but is also found in many other samples. Most references to this species mention an opaque dorsal side in which detail is obscured by a thick deposit of laminated calcite. At Cape Grim, as well as such opaque specimens, there are many well preserved specimens in which most detail is clear through translucent calcite.

In most of the samples from Cape Grim, in addition to typical *D. balcombensis*, there is a variety which deserves comment. It occurs in all Cape Grim samples but not in samples from other areas. It has the same variation in preservation as typical *D. balcombensis*. The best material is from 84008, where it is well preserved and not opaque. It is distinct from typical *D. balcombensis* in having a border of coarse pores to the dorsal part of each chamber, a coarsely perforate ventral part of each chamber and slightly posteriorly directed ventral intercameral sutures which have more strongly recurved distal part. There appears to be less variation in maximum diameter/thickness ratio than in typical *D. balcombensis*. It has a very distinct umbilical plug. The entire ventral surface gives the appearance of being much more heavily thickened than in typical *D. balcombensis*. Twenty one specimens of this variety were recovered from 84008. They have been measured for maximum diameter and thickness and the results are plotted in figure 1. Average length is 0.48 mm with a range from 0.35 to 0.77 mm. Average thickness is 0.25 mm with a range from 0.20 to 0.37 mm.

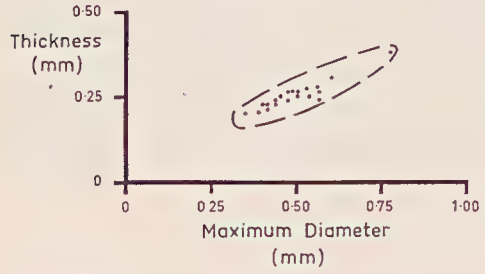

FIG.1 - Thickness vs maximum diameter for *Discorbis balcombensis* Chapman, Parr and Collins

Occurrence - (a) Mussel Roe Bay - 84483 (q), 84481 (r), 84482 (f),
(b) Fossil Bluff - Freestone Cove Sandstone, 84010b (v),
(c) King Island - 84475 (r),
(d) Cape Grim - Cape Grim Beds, 84008 (a), 84007 (a), 84006 (c), 84005 (f), 84003 (f), 84002 (c), 84001 (c),

(e) Granville Harbour - 54144 (r),
(f) Preservation Island - 84479 (q),
(g) Cape Barren Island - 84554 (f),
(h) Marrawah district - 84092 (f), 84561 (r), 84109 (r), 84101 (v), 84105 (q), 84107 (q).

Age - Late Oligocene - Early Miocene, N3-N8.

Discorbis barkeri Mohan and Bhatt, 1968
(Pl. 3, figs. 9, 10)

Discorbina rosacea (d'Orbigny); Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.* 9, pl. 87, figs. 41-c.

Discorbis sp. nov.; Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9 (180), pl. 87, figs. 4a-c.

Discorbis barkeri Mohan and Bhatt, 1968, *Proc. Nat. Inst. Sci. India*, 34 (B), no. 4, 180, pl. 15, figs. 1a-c.

Type locality and stratigraphic level - *Challenger* Station 162, Bass Strait, Recent.

Occurrence - Mussel Roe Bay - 84481 (r)

Age - Early Miocene, N4/5.

Discorbis spp. indet.

Remarks

Three Marrawah samples and that from Cape Portland contained poorly preserved, unidentifiable specimens.

Occurrence - (a) Cape Portland - 84553 (r),
(b) Marrawah district - 84561 (r), 84111 (r), 84113 (r).

Age - Early Miocene.

Genus EPISTOMINELLA Husezima and Maruhasi, 1944

Epistominella iota Hornibrook, 1961
(Pl. 3, figs. 14-16)

Epistominella iota Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 122, pl. 17, figs. 359, 361, 363.

Type locality and stratigraphic level - Hutchinsons Quarry, Oamaru, New Zealand, Late Oligocene-Early Miocene.

Occurrence - Brittons Swamp - 84480 (v).

Age - Early Miocene, N8

Epistominella shauni Quilty, n. sp.
(Pl. 3, figs. 17-19)

Diagnosis

Epistominella with five to six chambers in the final whorl; the dorsal surface of each chamber with three to four rows of very coarse pores with 16-20 pores in each row. Test with a maximum diameter/thickness ratio of 1.65. Dorsal surface usually more convex than ventral which is almost flat.

Description

Test free, lenticular, roughly circular in plan, trochospiral throughout. Dorsal surface generally a little more convex than ventral. Maximum diameter/thickness ratio 1.65. Dorsal surface evolute, showing 2-2½ whorls with five to six chambers in the final whorl. Proloculus small, about 0.08 mm or less in diameter; covered by a considerable deposit of laminated calcite. Dorsal sutures flush or slightly elevated or depressed; obvious due to their being imperforate and thus different in structure from the rest of the surface. Spiral suture not lobulate. Intercameral sutures very strongly recurved posteriorly distally, the angle of recurvature in adult chambers being of the order of 110°. Early sutures are almost straight, radial and become progressively more strongly recurved during ontogeny. Dorsal surface of each chamber very coarsely perforate. In adult chambers these pores are arranged in three to four rows parallel to the strongly curved anterior intercameral sutures. There are 16-20 pores in each such row in adult chambers but earlier chambers are much less strongly perforate, there being very few which penetrate the central thickened area in the centre

of the dorsal surface. Margin of test quite sharp but rounded and imperforate. Ventral surface involute with central flush umbilical boss. Ventral surface of chambers imperforate in strong contrast to the dorsal surface. Intercameral sutures recurved throughout their length, the amount of recurvature increasing distally at a uniform rate. Septa appear to be thicker proximally, so that the central ventral parts of the sutures are broader and this area has a stellate appearance. Proximal part of each chamber extends to umbilical boss. Aperture in the anterior face of each chamber, completely ventral, mainly an interiomarginal slit without lip, but distally forming a short narrow slit directed away from the suture and becoming parallel to the periphery of the test. This slit is depressed in a 'tucked in' part of the apertural face. With the addition of a new chamber, the apertural face is much resorbed and made into a large, high-arched septal foramen. The aperture is single.

Remarks

Only twelve specimens of the species were recovered, as follows:

(a) Fossil Bluff - Fossil Bluff Sandstone 84011 - 1 specimen (v),
Freestone Cove Sandstone 84012 - 2 specimens (r),
84025a- 3 specimens (r),
84025b- 1 specimen (v);

(b) Mt. Cameron West - 84121 - 2 specimens (v),
84120 - 2 specimens (v);

(c) Marrawah district - 84561 - 1 specimen (v).

All were measured for maximum diameter and thickness, and the results plotted (fig. 2). Average maximum diameter is 0.26 mm with a range from 0.19 to 0.37 mm. Average thickness is 0.16 mm with a range from 0.09 to 0.22 mm.

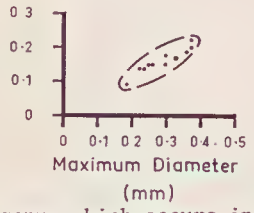

FIG. 2 - Thickness vs maximum diameter for *Epistominella shauni* n. sp.

The species differs from a new species of this genus which occurs in the Late Eocene of southwestern Australia in having only five to six chambers in the final whorl, in being often more convex dorsally, and in being always imperforate on the ventral surface. It also has a lower maximum diameter/thickness ratio.

This species seems closely related to *Svratkina* Pokorny, and it is probable that the genus belongs in the Discorbidae rather than in the Alabaminidae.

There are two groups of species within *Epistominella*. One includes the type species and *E. dubia* Haque (Paleocene), *E. shauni* Quilty (Miocene), *E. pulchra* (Cushman (Recent) and others. The other group contains *E. iota* Hornibrook and could be distinguished as the genus, *Pseudoparrella* Cushman and Ten Dam.

The species is named from a holotype and six paratypes. It is named in honour of my son, Shaun, who was born on the day this description was first penned.

Age - Early Miocene, N4/5.

Genus SVRATKINA Pokorny, 1956

Svratkina australiensis (Chapman, Parr and Collins), 1934
(Pl. 3, figs. 20, 21)

Discorbis tuberculata(Balkiwill and Wright); Heron-Allen and Earland, 1924, *J. R. microsc. Soc.* (1924), 169.

Discorbis tuberculata (Balkiwill and Wright) var. *australiensis* Chapman, Parr and Collins, 1934, *J. Linn. Soc.*, 38 (262), 563, pl. 8, figs. 9a-c.

Discorbis tuberculata (Balkiwill and Wright) var. *australiensis*; Crespin, 1943, *Palaeont. Bull.*, Canberra 4, 79.

Svratkina australiensis (Chapman, Parr and Collins); Pokorny, 1956, *Univ. Carolina*,

Geologica, 2 (3), 257, figs. 1-3.
Alabamina australiensis (Chapman, Parr and Collins); Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 115, pl. 11, figs. 217-219.
Svratkina australiensis (Chapman, Parr and Collins); Loeblich and Tappan, 1964, *Treat. Invert. Palaeont.*, C2(2), C750, fig. 614, 8a-c.
Type locality and stratigraphic level - Altona Coal Shaft, Port Phillip, Victoria, Miocene.
Occurrence - Marrawah district - 84561 (v).
Age - Early Miocene, N4/5.

Genus GAVELINOPSIS Hofker, 1951
Gavelinopsis pukeuriensis Hornibrook, 1961
(Pl. 3, figs. 22, 23)

Gavelinopsis pukeuriensis Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 104, pl. 13, figs. 267, 270, 271.
Type locality and stratigraphic level - Pukeuri Township, New Zealand, Early Miocene.
Remarks
Two imperfectly preserved specimens are tentatively referred to this species. The ventral aspect is identical with that of Hornibrooks' type figure, and the dorsal side is very similar. However, the lateral profile lacks the keel of *G. pukeuriensis*.
Occurrence - Mussel Roe Bay - 84481 (v).
Age - Early Miocene, N4/5.

Genus LATICARININA Galloway and Wissler, 1927
Laticarinina altocamerata (Heron-Allen and Earland), 1922
(Pl. 3, figs. 24, 25)

Truncatulina tenuimargo var. *altocamerata* Heron-Allen and Earland, 1922, *Br. Antarct. ("Terra Nova") Expedn 1910, Zool.*, 6 (2), 209, pl. 7, figs. 24-27.
Parvicarinina altocamerata (Heron-Allen and Earland); Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 118, pl. 14, figs. 296, 299, 301, 302, 305.
Type locality and stratigraphic level - locality not designated, various localities near New Zealand, Recent.
Remarks
A single well preserved specimen was recovered from Cape Grim (84008 (v)) and is tentatively placed here.
Age - Early Miocene, N4/5.

Genus PLANODISCORBIS Bermudez, 1952
Planodiscorbis macropora Carter, 1964
(Pl. 3, figs. 26, 27)

Planodiscorbis macropora Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 89, pl. 6, figs. 113-115.
Type locality and stratigraphic level - Brocks Quarry, Glencoe, Victoria, Early Miocene.
Occurrence - (a) King Island - 84081 (v), 84083 (v),
(b) Marrawah district - 84561 (v).
Age - Early Miocene, N4/5.

Genus PLANULINOIDES Parr, 1941
Planulinoides biconcavus (Jones and Parker), 1862
(Pl. 3, fig. 28)

Discorbina biconcava Jones and Parker (in Carpenter, Parker and Jones) 1862, AN INTRODUCTION TO THE STUDY OF THE FORAMINIFERA, *Ray Soc. Publs* (1862), 201, tab. 32g.
Discorbina biconcava; Parker and Jones, 1865, *Phil. Trans. R. Soc.*, 155, pl. 19 figs. 10a-c.
Discorbina biconcava; Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 12.
Discorbina biconcava; Howchin, 1891, *Trans. Proc. R. Soc. S. Aust.*, 14, 352.
Discorbina biconcava; Heron-Allen and Earland, 1924, *J. R. microsc. Soc.* (1924), 173.

Planulinoides biconcavus (Jones and Parker); Parr, 1941, *Min. geol. J.*, 2 (5), 305, text, fig.
Planulinoides biconcavus; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 82.
Discorbinella biconcava (Jones and Parker); Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 86, pl. 5, figs. 97-100.
Planulinoides biconcava; Loeblich and Tappan, 1964, *Treat. Invert. Paleont.*, C2(2), C584, fig. 458, 4-6.
Discorbinella biconcava; Reed, 1965, *Bull. Am. Paleont.*, 49 (22), 69.
Type locality and stratigraphic level - shore sand, Melbourne, Victoria, Recent.
Remarks
Although Loeblich and Tappan (1964a, *op. cit.*) regard *Planulinoides* as a Pliocene-Recent genus, records of the type species were known from pre-Pliocene rocks as long ago as 1889 (Howchin 1889).
Occurence - (a) Mussel Roe Bay - 84483 (v),
(b) Mt Cameron West - 84120 (v),
(c) Marrawah district - 84104 (v).
Age - Late Oligocene-Early Miocene, N3-N8.

Genus ROSALINA d'Orbigny, 1826
Sugbenus NEOCONORBINA Hofker, 1951
Rosalina (Neoconorbina) terquemi (Rzehak), 1888
(Pl. 4, figs. 3-6)

Rosalina orbicularis Terquem, 1876, ESSAI SUR LE CLASSEMENT DES ANIMAUX QUI VIVENT SUR LE PLAGE ET DANS LES ENVIRONS DE DUNKERQUE, (The author: Paris) (2), 75. (Not *Rosalina orbicularis* d'Orbigny, 1850).
Discorbina terquemi Rzehak, 1888, *Verh. K.K. geol. Reichensanst., Wien* (1888) 228.
Rosalina terquemi; Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 101, pl. 13, fig. 272.
Type locality and stratigraphic level - not designated, Mouchy-le-Chatel France, Early Eocene.
Occurrence - (a) Mussel Roe Bay - 84481 (r), 84482 (v),
(b) Brittons Swamp - 84480 (v).
Age - Early Miocene, N4-N8.

Rosalina (Neoconorbina) turbinata (Terquem), 1882
(Pl. 4, figs. 1, 2, 7, 8)

Rotalina turbinata Terquem, *Mem. Soc. geol. Fr.* no. 3, ser. 3, 2, 75, pl. 7, figs. 5a, b.
Discorbis turbinata (Terquem); Le Calvez, 1949, *Mem. Serv. Carte geol. de. Fr.* (1949), 22, pl. 3, figs. 45-47.
Type locality and stratigraphic level - Vandancourt, France, Eocene.
Remarks
The features of the central part of the dorsal surface of this species are not clear in the specimens available. However, the overall shape, ventral features and peripheral dorsal features all match *R. turbinata* well.
Occurrence - (a) Mussel Roe Bay - 84481 (r), 84482 (q), 84483 (v),
(b) King Island - 84084 (q),
(c) Cape Barren Island - 84554 (r),
(d) Marrawah district - 84110 (r), 84114 (r), 84104 (r).
Age - Late Oligocene - Early Miocene, N3-N8.

Subgenus ROSALINA d'Orbigny, 1826
Rosalina (Rosalina) mitchelli Carter, 1964
(Pl. 4, figs. 9, 10)

Rosalina mitchelli Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 73, pl. 3, figs. 54, 55, 56.
Type locality and stratigraphic level - Rosehill, Mitchell River, Victoria, Late Miocene.
Remarks
The specimens recovered are often identical with Carter's (1964, *op. cit.*) figures,

except that there appears to be no ventral imperforate area other than the umbilical flaps, on most specimens.
Occurrence - Cape Grim - Cape Grim Beds, 84008 (q), 84007 (r), 84001 (r).
Age - Early Miocene, N4/5.

Rosalina (Rosalina) vilardeboana d'Orbigny, 1839
(Pl. 4, figs. 11, 12)

Rosalina vilardeboana d'Orbigny, 1839, VOYAGE DANS L'AMERIQUE MERIDIONALE FORAMINIFERES, (P. Levrault: Strasbourg), 5, 44, pl. 6, figs. 13-15.
Type locality and stratigraphic level - Falkland Islands, Recent.
Occurrence - Marrawah district (84561 (r)).
Age - Early Miocene, N4/5.

Rosalina (Rosalina) spp.
(pl. 4, figs. 13, 14)

Remarks
A well preserved, unidentified (possibly new) species of *Rosalina* was recovered from Cape Grim. Another was found at King Island. The latter is of the *R. mitchelli* type but is smaller and more finely perforate.
Occurrence - (a) King Island - 84475 (v),
(b) Cape Grim - Cape Grim Beds, 84006 (v).
Age - Early Miocene, N4/5.

Subfamily BAGGININAE
Genus BAGGINA Cushman, 1926
Baggina sp. cf. *B. philippinensis* (Cushman), 1921
(Pl. 4, figs. 15, 16)

cf *Pulvinulina philippinensis* Cushman, 1921, *Bull. U.S. natn. Mus.*, 4, (100), 331, pl. 58, fig. 2.
cf *Cancris philippinensis* (Cushman); Parr, 1939, *Min. geol. J.*, 1, (4), 69, pl. 1, figs. 18a-c.
cf *Cancris philippinensis;* Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 77.
cf *Baggina philippinensis* (Cushman); Cushman and Todd, 1944, *Contr. Cushman Lab. foramin. Res.*, 20 (4), 105, pl. 17, figs. 1-3.
Baggina philippinensis; Carter, 1964, *Mem. Geol. Surv. Vict.*, 23, 85, pl. 5, figs. 94-96.
Type locality and stratigraphic level (*B. philippinensis*) - Verde Island Passage, Philippines, Recent.
Remarks
The species recorded here seems to be the same as that recorded previously from Australia. However, I am not sure that it is *B. philippinensis*. Cushman and Todd (1944, p.104) noted that *B. philippinensis* has four to five, usually, four, chambers in the final whorl and figured specimens with four to five, whereas Carter (1964, p.85) stated that the Australian species has five to six, and he illustrated a specimen with six. Parr (1939, pl. 1, fig. 18) figured a specimen with five. Cushman and Todd neither mentioned nor illustrated the deeply incised proximal parts of the ventral intercameral sutures - quite a noticeable feature of the Australian species.
Occurrence - (a) Fossil Bluff - Fossil Bluff Sandstone, 84025b (v),
(b) Cape Grim - Cape Grim Beds, 84005 (v),
(c) Mt. Cameron West - 84118 (v).
Age - Early Miocene, N4/5.

Genus CANCRIS de Montfort, 1808
Cancris intermedius Cushman and Todd, 1942
(Pl. 4, figs. 17, 18)

Cancris auricula (Fichtel and Moll); Chapman, Parr and Collins, 1934, *J. Linn. Soc.*, 38, 567, pl. 10, figs. 24a-c.
Cancris intermedius Cushman and Todd, 1942, *Contr. Cushman. Lab. foramin. Res.*, 18 (4),

88, 89, pl. 22, figs. 11, 12.
Cancris ovatus Cushman and Todd, 1942, *ibid.*, 89, 90, pl. 23, figs. 1, 2.
Cancris intermedius; Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 84, pl. 5, figs. 90-93.
Cancris intermedius; Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 78.
Type locality and stratigraphic level - Western Beach, Geelong, Victoria, Miocene.
Occurrence - Fossil Bluff - Fossil Bluff Sandstone, 84019 (q), 84022 (v), 84025a (v).
Age - Early Miocene, M4/5.

Cancris laevinflatus Hornibrook, 1961
(Pl. 4, figs. 19, 20)

Cancris laevinflatus Hornibrook, 1961, *Palaeont. Bull.* , Wellington, 34 (1), 120, pl. 15, figs. 330-332.
Type locality and stratigraphic level - Otiake, New Zealand, Late Oligocene.
Occurrence - (a) Mussel Roe Bay - 84483 (r), 84481 (v),
(b) Fossil Bluff - Freestone Cove Sandstone, 84010a (v), 84010b (v);
Fossil Bluff Sandstone, 84011 (v), 84012 (r), 84014 (v).
(c) Mt. Cameron West - 84120 (v),
(d) Cape Barren Island - 84554 (v),
(e) Marrawah district - 84092 (v), 84561 (v).
Age - Late Oligocene - Early Miocene, N3-N8.

Genus VALVULINERIA Cushman, 1926
Valvulineria sp.
(Pl. 4, figs. 21, 22)

Remarks
Two specimens somewhat similar to *V. stachei* Hornibrook, were recovered from Fossil Bluff (lower Fossil Bluff Sandstone, 84011, v), and one from Preservation Island (84479). They differ from *V. stachei* in having a more angular periphery and in having a more conical, evolute dorsal side.
Age - Early Miocene, N4/5, N8.

Family GLABRATELLIDAE
Genus ANGULODISCORBIS Uchio, 1953
Angulodiscorbis ludbrookae Quilty, n. sp.
(Pl. 4, figs. 23-25)

Diagnosis
Angulodiscorbis with diameter/spire height ratio of 0.80 and average apical angle of 50°. Test of five whorls, four chambers per whorl. Dorsal surface smooth with depressed sutures and lacking ridges from apex to ventral margin. Ventral surface with large central depression made up of apertures of each chamber.
Description
Test free, a high trochospire, almost conical. Margin of base rounded. Diameter/spire height ratio averages 0.80. Dorsal surface evolute, a high spire, showing five whorls of chambers, four chambers in each of the last four whorls, the details of the first being difficult to see. The equivalent chambers of each whorl form a regular series from apex to base. Apical angle averages 50°. Apex slightly rounded. Apical area sometimes 'ornamented' with minute tubercles. Chambers increase slowly in size. Sutures slightly but clearly depressed. Intercameral sutures recurved posteriorly distally. Surface smooth. Wall finely perforate. Ventral surface involute with central depression and cavity formed of apertures of each chamber. The cavity in the centre of the ventral surface is circular and makes up an appreciable amount of the ventral area. Intercameral sutures straight, radial, slightly depressed. Ventral aspect of chambers globular, inflated. Ventral surface ornamented with fine radial striae.
Remarks
Of fifteen specimens recovered, thirteen are from Fossil Bluff and two from Mussel Roe Bay. Of these, two are from 84010a, nine from 84010b, and one each from 84012, 84025a, 84483 and 84481. Ten are preserved well enough for diameter, spire height and

apical angle to be measured. Average diameter is 0.12 mm with a range from 0.18 mm to 0.24 mm. Average spire height is 0.26 mm with a range from 0.21 mm to 0.29 mm. Apical angle varies from 35° to 50°.

The choice of generic assignation lies between *Glabratella* Dorreen and *Angulodiscorbis* Uchio. The species is not placed in *Pileolina* as it has a rounded margin to the base of the cone. In overall growth pattern, size, etc., it is very similar to *Angulodiscorbis quadrangularis* Uchio. It differs from that species in having more inflated chambers, no striae on the dorsal surface and in being much less quadrangular in section, having no clear ridges on the dorsal surface. Also the dorsal surface is not straight in axial section but is a little convex. The aperture is relatively larger than that of *A. quadrangularis*. It is quite clearly congeneric with *Angulodiscorbis*, but whether *Angulodiscorbis* is a genus in its own right or a subgenus of *Glabratella*, is not so clear. The only notable distinction between the genera seems to be the spire height. As no intermediate forms are obvious between low spired *Glabratella* and high spired *Angulodiscorbis*, the latter name is used. None of the specimens recovered shows any evidence of plastogamy. The type sample (Holotype and 5 paratypes) is taken entirely from 84010b.

Occurrence - (a) Mussel Roe Bay - 84483 (v), 84481 (v),
(b) Fossil Bluff - Freestone Cove Sandstone, 84010a (v), 84010b (r);
Fossil Bluf Sandstone, 84012 (v), 84025a (v).

Age - Late Oligocene - Early Miocene N3-N5.

Repository - (a) Holotype - U.T.G.D. 84355.
(b) Figured paratype - U.T.G.D. 84357
(c) Other paratypes U.T.G.D. 84352-54, 84356.

Angulodiscorbis sp. 2
(Pl. 4, figs. 26, 27)

Remarks

As well as the species described herein as *A. ludbrookae*, there is a single specimen of another, apparently new species from Mussel Roe Bay (84482). This species has a definite recticulate pattern over all the dorsal surface of the test.

Age - Early Miocene, N4/5.

Genus BUENINGIA Finlay, 1939
Bueningia creeki Finlay, 1939
(Pl. 5, figs. 1, 2)

Büningia creeki Finlay, 1939, *Trans. R. Soc. N.Z.*, 69 (1), 122, pl. 14, figs. 82-84.
Bueningia creeki; Loeblich and Tappan, 1964, *Treat. Invert. Paleont.*, C2(2), C589, fig. 464, 6.

Type locality and stratigraphic level - Greymouth, New Zealand, Late Oligocene.

Remarks

A single specimen identical with Loeblich and Tappan's (1964a) figure was recovered from Mussel Roe Bay (84483 (v)).

Age - Late Oligocene, N3.

Genus GLABRATELLA Dorreen, 1948

In this work, the genus *Glabratella* is used in the sense of Dorreen's (1948, p.294) diagnosis of it. His diagnosis is as follows:

"Test inflated, a trochoid spire of few whorls; *chambers globose;* dorsal surface slightly roughened to ornamented; ventral surface smooth, with fine radial striae". (Italics mine).

If only those species with globose chambers are included, *Pileolina* cannot be accepted as a synonym, as species referred to *Pileolina* are generally conical, with non-globular chambers, and with an angled margin, in contrast to *Glabratella* which is not conical, has globular chambers and has a very rounded margin.

Even though the apertural characters of *Valvulina pileolus* may not be well known, there seems ample reason for separating *Pileolina* from *Glabratella*. A more reasonable position for *Pileolina* would appear to be in synonymy with *Discorbis*, as assigned by

Hornibrook (1961, p.98). Following Loeblich and Tappan (1964a, p.C589) *Conorbella* is considered a synonym of *Glabratella*, but *Pileolina* is regarded as a genus in its own right.

From the samples studied, five groups of *Glabratella* have been separated. The dominant, most widespread group is typical *Glabratella crassa* Dorreen, characterised by a globular test and dorsal sutures which are only very little depressed. Another easily identified species is *G. cruciformis* (Howchin). A third is probably *G. globigeriniformis* (Heron-Allen and Earland). The other two groups are rare and possibly new species but are only recorded informally.

Glabratella crassa Dorreen, 1948
(Pl. 5, figs. 3, 4)

Glabratella crassa Dorreen, 1948, *J. Paleont.*, 22 (3), 294, pl. 39, fig. 1.
Glabratella crassa; Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 108, pl. 14, fig. 289.
Glabratella crassa; Loeblich and Tappan, 1964, *Treat. Invert. Paleont.*, C2(2), C588. fig. 464, 1.
Type locality and stratigraphic level - Near Greymouth, New Zealand, Late Eocene.
Remarks
This is the most abundant *Glabratella* in the Tasmanian Tertiary occurring mainly in the Cape Grim section. It commonly has a somewhat flattened central part to the ventral surface. This is construed as being formed during an attached life or as a result of a plastogamic union. The latter is a little unlikely as no plastogamic pairs have been recorded.
The figured specimen shows weak development of dorsal sculpture.
Occurrence - (a) Mussel Roe Bay - 84483 (v), 84481 (r),
(b) Fossil Bluff - Fossil Bluff Sandstone, 84012 (v),
(c) King Island - 84084 (v), 84477 (r),
(d) Cape Grim - Cape Grim Beds, 84008 (q), 84007 (q), 84006 (q), 84005 (r), 84002 (v), 84001 (r),
(e) Granville Harbour - 54144 (q),
(f) Marrawah district - 84561 (v).
Age - Late Oligocene - Early Miocene, N3-N8.

Glabratella cruciformis (Howchin), 1889
(Pl. 5, figs. 5, 6)

Discorbina cruciformis Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 12, 13, pl. 1, figs. 13, 14.
Discorbina cruciformis; Heron-Allen and Earland, 1924, *J. R. microsc. Soc.* (1924), (2), 171, pl. 11, figs. 74-77.
Glabratella cruciformis (Howchin); Dorreen, 1948, *J. Paleont.*, 22, 294.
Type locality and stratigraphic level - Muddy Creek, Victoria, Miocene.
Remarks
This is probably the most easily identified species of this genus and is distinguished by its strongly tuberculate dorsal surface.
Occurrence - (a) Mussel Roe Bay - 84481 (v),
(b) Fossil Bluff - Freestone Cove Sandstone, 84010a (r),
(c) Cape Grim - Cape Grim Beds, 84008 (v), 84006 (r), 84005 (v),
(d) Preservation Island - 84479 (r).
Age - Early Miocene, N4/5, N8.

Glabratella globigeriniformis (Heron-Allen and Earland), 1924
(Pl. 5, figs. 7, 8)

Discorbina globigeriniformis Heron-Allen and Earland, 1924, *J. R. microsc. Soc.* (1924), (2), 171, pl. 13, figs. 96-98.
Glabratella globigeriniformis (Heron-Allen and Earland); Dorreen, 1948, *J. Paleont.*, 22, 294.
Type locality and stratigraphic level - "Filter Quarry" Moorabool River, Victoria,

Miocene.

Remarks

From Cape Grim (84008, (r) and 84005, (r)) a few specimens of a species with a lower trochospire than *G. crassa*, five chambers in the final whorl and a distinct dorsal sutures, are referred to this species. The dorsal surface is a little roughened but not so much as is suggested by Heron-Allen and Earland's figures. The aperture is relatively larger than those shown in the type figures.

Age - Early Miocene, N4/5.

Glabratella sp. 1
(Pl. 5, figs. 9, 10)

Remarks

A single specimen of an apparently undescribed species was recovered from Fossil Bluff (Fossil Bluff Sandstone, 84012). It is distinct from other species in that it has a low trochospiral growth form, low rate of increase of chamber size, five chambers in the final whorl, a small umbilical depression and a higher maximum diameter/thickness ratio than is normal for *Glabratella*.

Age - Early Miocene, N4/5.

Glabratella sp. 2
(Pl. 5, figs. 11, 12)

Remarks

A single specimen of an apparently undescribed species was recovered from King Island (84084). It is a robust specimen with a low domed dorsal surface with a series of nodes on it. The ventral surface is a truncate cone, the truncation representing the margin of the umbilicus, which is made up of a series of apertures. The truncated part of the cone has a depressed centre and the radial striae, characteristic of the family are restricted to the interior sides of the depression.

The general features of the specimen suggest a possible relationship with *Schackoinella wadeae* Quilty (Quilty 1975).

Age - Early Miocene, N4/5.

Genus HERONALLENIA Chapman and Parr, 1931

Heronallenia lingulata (Burrows and Holland), 1895
(Pl. 5, figs. 13, 14)

Discorbina lingulata Burrows and Holland, (*in* Jones) 1895, *Palaeontogr. Soc. Monogr.* (1895), pl. 7, figs. 33a-c.

Heronallenia lingulata (Burrows and Holland); Chapman, Parr and Collins, 1934, *J. Linn. Soc.*, 38, 564, 565, pl. 8, figs. 11a-c.

Heronallenia lingulata; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.

Heronallenia lingulata; Carter, 1958, *Bull. geol. Surv. Vict.*, 55, 42, 43, pl. 5, figs. 40-42.

Heronallenia lingulata; Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 92, pl. 6, figs. 124-126.

Heronallenia lingulata; Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 69.

Type locality and stratigraphic level - England, Pliocene.

Occurrence - (a) Mussel Roe Bay - 84481 (v),
(b) Cape Grim - Cape Grim Beds, 84008 (v), 84006 (v), 84001 (v),
(c) Mt. Cameron West - 84121 (v), 84120 (v),
(d) Brittons Swamp - 84480 (v),
(e) Marrawah district - 84092 (v), 84113 (v), 84104 (v).

Age - Early Miocene, N4-N8.

Heronallenia parri Carter, 1958
(Pl. 5, figs. 15, 16)

Discorbina wilsoni Heron-Allen and Earland, 1924, *J.R. microsc. Soc.* (1924) (2), 172. (Not Heron-Allen and Earland, 1922).

Heronallenia wilsoni (Heron-Allen and Earland); Chapman and Parr, 1931, *Proc. R. Soc. Vict.* n.s. 43 (2), 237, pl. 9, fig. 7.
Heronallenia wilsoni; Chapman, Parr and Collins, 1934, *J. Linn. Soc.*, 38, 564, pl. 8, figs. 12a-c.
Heronallenia wilsoni; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 80.
Heronallenia parri Carter, 1958, *Bull. geol. Surv. Vict.*, 55, 43, 44, pl. 5, figs. 43-45.
Heronallenia parri; Carter, 1964, *Mem. geol. Surv. Vict.*, 23, 92, 93.
Heronallenia parri; Reed, 1965, *Bull. Am. Paleont.*, 49 (220), 69.
Type locality and stratigraphic level - Aire Coast, Victoria, Late Oligocene.
Occurrence - (a) Mussel Roe Bay - 84483 (r),
(b) Fossil Bluff - Fossil Bluff Sandstone, 84011 (v), 84025a (v), 84024 (r),
(c) King Island - 84085 (v),
(d) Cape Grim - Cape Grim Beds, 84006 (v),
(e) Granville Harbour - 54144 (r),
(f) Redpa - 84095 (v),
(g) Cape Barren Island - 84554 (v),
(h) Marrawah district - 84110 (v).
Age - Late Oligocene - Early Miocene, N3-N8.

Genus PILEOLINA Bermudez, 1952

General Remarks

As stated before in this work, *Glabratella* is used in the sense that it was defined by Dorreen (1948).

If only those species with globose chambers are included, *Pileolina* cannot be accepted as a synonym, as species referred to *Pileolina* are generally conical, with nonglobular chambers, and with an angled margin, in contrast to *Glabratella* which is not conical, has globular chambers and has a very rounded margin.

Even though the apertural characters of *Valvulina pileolus* may not be well known, there seems ample reason for separating *Pileolina* from *Glabratella*. Hornibrook placed *Pileolina* in synonymy with *Discorbis*, the best allocation if *Pileolina* is not a valid genus. However, *Pileolina* is here regarded as a genus in its own right as noted earlier (see *Glabratella*).

Furthermore, rather than place *Pileolina* in the Glabratellidae, it could well be regarded as belonging to the Discorbidae. The bases on which it was placed in the Glabratellidae by Loeblich and Tappan are (a) it must have an umbilical aperture, (b) it has a flattened or concave, radially striate or grooved ventral surface, (c) it has triflagellate gametes, and (d) it commonly exhibits plastogamy.

Many of the species referred to *Pileolina* do not have an indisputably umbilical aperture. Many of the specimens found here appear to have an interiomarginal aperture. This is a character compatible with a position in the Discorbidae.

A flattened or concave ventral surface is a common character in the Discorbidae and there seems to me no reason why a radially striate surface should be restricted to the Glabratellidae. *Discorbinella bertheloti* (*q.v.*) occasionally has a radially striate ventral surface.

The triflagellate gamete character for the Family Glabratellidae is probably based on *Pileolina patelliformis* so this character goes wherever the species goes.

The only problem with the transfer of this genus to the Discorbidae is that of plastogamy. Plastogamy does not appear to be common in the Discorbidae, and this is the only character which is here regarded as being very significant.

Pileolina australensis (Heron-Allen and Earland), 1932

(Pl. 5, fig. 17)

?Discorbina pileolus; Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 12. (not *D. pileolus* Brady 1884).
?Discorbina pileolus; Chapman, 1910, *Proc. R. Soc. Vict.* n.s., 22, 282.
?Discorbina pileolus; Heron-Allen and Earland, 1924, *J.R. microsc. Soc.* (1924) (2), 170.

Discorbis australensis Heron-Allen and Earland, 1932, *"Discovery" Repts*, 4 (1), 416.
Discorbis pileolus (Heron-Allen and Earland); Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 79.
Pileolina (?) *australensis* (Heron-Allen and Earland);BBarker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa, 9, 184, pl. 89, figs. 2-4.
Type locality and stratigraphic level - Challenger Station 163B, Port Jackson, Recent.
Remarks
This is the same species as figured by Barker (1960 *op. cit.*). It is a common species in the Cape Grim section and several hundred specimens have been recovered, up to 2/3 of specimens being recovered in plastogamic pairs. The single specimen from Marrawah (84114, (v)) is only tentatively identified.
Occurrence - (a) Cape Grim - Cape Grim Beds, 84008 (c), 84007 (q), 84006 (v), 84005 (r) 84003 (v), 84002 (q), 84001 (f),
(b) Marrawah district - 84114 (v).
Age - Early Miocene, N4-N8.

Pileolina sp. cf. *P. opercularis* (d'Orbigny), 1839
(Pl. 5, figs. 18, 19)

Discorbina opercularis d'Orbigny; Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 650, pl. 89, figs. 8, 9. (?*D. opercularis*, d'Orbigny, 1839).
Discorbina opercularis; Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 12.
Discorbina opercularis; Chapman, Parr and Collins, 1934, *J. Linn. Soc.*, 38, 562, pl. 8, figs. 8a-c.
Discorbina opercularis; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 78.
Pileolina (?) *opercularis* (d'Orbigny); Barker, 1960, *Spec. Publs Soc. econ. Paleont. Miner.*, Tulsa 9, 184, pl. 89, figs. 8, 9.
Type locality and stratigraphic level (*P. opercularis*)-Cuba, Recent.
Remarks
This species is the same described and figured by Brady (1884, *op. cit.*) and Barker (1960, *op. cit.*) and is fairly clearly that recorded by all authors listed in the synonymy. It does seem to be different from the species described by d'Orbigny (1839, p.93) in having only eight or nine chambers in the final whorl whereas *P. opercularis* has at least ten to eleven. However, until d'Orbigny's species is known better, no authoritative definition of a new species could be made.
Commonly, more than half the specimens recovered are in the form of plastogamic pairs. The species is mainly restricted to the Cape Grim section where it is quite common.
Occurrence - (a) Cape Grim - Cape Grim Beds 84008 (f), 84007 (c), 84006 (f), 84005 (f), 84003 (v), 84002 (r), 84001 (q),
(b) Preservation Island - 84479 (q).
Age - Early Miocene, N4/5, N8.

Pileolina.patelliformis (Brady), 1884
(Pl. 5, figs. 20-23)

Discorbina patelliformis Brady, 1884, *"Challenger" Expedn, Scient. Results, Zool.*, 9, 647, pl. 89, fig. 1.
Discorbina patelliformis; Howchin, 1889, *Trans. Proc. R. Soc. S. Aust.*, 12, 12.
Discorbina patelliformis; Heron-Allen and Earland, 1924, *J. R. microsc. Soc.* (1924), (2), 170.
Discorbis patelliformis; Crespin, 1943, *Palaeont. Bull.*, Canberra, 4, 78.
Type locality and stratigraphic level - South of Papua, Pacific Ocean, Recent.
Remarks
Figure 3 is a plot of thickness against maximum diameter. The 28 specimens measured are all from Fossil Bluff (84011).
The species is most similar to *Pileolina zealandica* Vella and differs only in the amount of recurvature of the dorsal intercameral sutures.
A distinction between this species and most other species of *Pileolina* is that no plastogamic pairs were recovered at all.

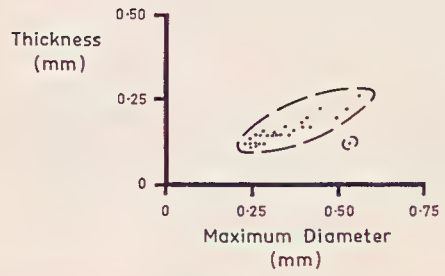

FIG. 3 -
Thickness vs maximum diameter for
Pileolina patelliformis (Brady)

Occurrence - (a) Fossil Bluff - Freestone Cove Sandstone, 84010a (f), 84010b (q); Fossil Bluff Sandstone, 84011 (f), 84012 (r), 84013 (q), 84016 (r), 84017 (r), 84025a (q), 84024 (r), 84025b (v);
(b) Cape Grim - Cape Grim Beds, 84008 (v), 84006 (v), 84003 (f), 84002 (r), 84001 (r),
(c) Mt. Cameron West - 84117 (r).
Age - Early Miocene, N4/5.

Pileolina zealandica Vella, 1957
(Pl. 5, figs. 24, 25)

Pileolina zealandica Vella, 1957, *Palaeont. Bull.*, Wellington, 28, 37, pl. 8, figs. 175, 176.
Discorbis zealandica; Hornibrook, 1961, *Palaeont. Bull.*, Wellington, 34 (1), 99, pl. 13, figs. 254-256.
Type locality and stratigraphic level - off Poor Knights Island, Cook Strait, New Zealand, Recent.
Remarks
The specimens found here suggest that the species is more variable than envisaged by Vella or Hornibrook. The number of chambers in the final whorl varies in these specimens from seven to eleven, a considerably higher range than given by them as five to eight. The figured specimens of Hornibrook and Vella fit well within the field of variation of maximum diameter and thickness of the species found here.
Occurrence - (a) Mussel Roe Bay - 84483 (q), 84481 (r), 84482 (r),
(b) Marrawah district - 84561 (v).
Age - Late Oligocene - Early Miocene, N3-N5.

Pileolina sp.
(Pl. 5, figs. 26, 27)

Remarks
Chalk-filled and thus somewhat indistinct specimens were recovered from the Marrawah district (84092 and 84104). They belong to a species which is distinct from most species of this genus in having a smaller rate of increase of chamber height and probably more whorls than most. It also has a much higher maximum diameter/thickness ratio than most species.
Occurrence - Marrawah district - 84092 (q), 84104 (r).
Age - Early Miocene, N4/5, N8.

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PLATE 1

Figure in parentheses is maximum dimension of figured specimen

FIG. 1. - *Valvulina* sp., Cape Barren Island; U.T.G.D. 84574, x 55; (approximately 0.5 mm); from U.T.G.D. 84544.
FIG. 2, 3.- *Lenticulina rotulata* Lamarck, Cape Barren Island; U.T.G.D. 84555, x 25; (1.1 mm); from U.T.G.D. 84544.
FIG. 4. - *Planularia* sp. Ann Bay, Marrawah; U.T.G.D. 84563, x 60; (0.45 mm); from U.T.G.D. 84561.
FIG. 5, 6. - *Cerobertina bartrumi* Finlay, Brittons Swamp; U.T.G.D. 84535, x 55; (0.50 mm); from U.T.G.D. 84480.
FIG. 7, 8. - *Lamarckina glencoensis* Chapman and Crespin, Cape Grim; U.T.G.D. 84398, x 35; (0.70 mm); from U.T.G.D. 84007.
FIG. 9, 10. - *Epistomina elegans* (d'Orbigny), Cape Grim; U.T.G.D. 84337, x 35; (0.76 mm; from U.T.G.D. 84008.
FIG. 11, 12.- *Mississippina concentrica* (Parker and Jones), Cape Grim; U.T.G.D. 84403, x 55 (0.50 mm); from U.T.G.D. 84008.
FIG. 13. - *Spirillina decorata* Brady, Brittons Swamp; U.T.G.D. 84505, x 70; (0.41 mm); from U.T.G.D. 84480.
FIG. 14, 15. - *S. inaequalis* Brady, Cape Grim; U.T.G.D. 84456, x 40; (0.67 mm); from U.T.G.D. 84003.
FIG. 16. - *S. unilatera* Chapman, Fossil Bluff; U.T.G.D. 84457, x 125; (0.23 mm); from U.T.G.D. 84012.
FIG. 17. - *Patellina corrugata* Williamson, Cape Grim; U.T.G.D. 84408, x 75; (0.35 mm); from U.T.G.D. 84008.
FIG. 18. - *Buliminella californica* Cushman, Fossil Bluff; U.T.G.D. 84243, x 40; (0.67 mm); from U.T.G.D. 84010a.
FIG. 19. - *B. elegantissima* (d'Orbigny), Fossil Bluff; U.T.G.D. 84244, x 30; (0.91 mm); from U.T.G.D. 84010a.
FIG. 20. - *B. madagascariensis* (d'Orbigny), Marrawah; U.T.G.D. 84245, x 85; (0.32 mm); from U.T.G.D. 84107.
FIG. 21. - *B. spicata* Cushman and Parker, Fossil Bluff; U.T.G.D.84246, x 30; (0.82 mm); from U.T.G.D. 84013.
FIG. 22. - *B.* sp., Mussel Roe Bay; U.T.G.D. 84491, x 80; (0.34 mm); from U.T.G.D. 84482.
FIG. 23, 24. - *Sphaeroidina bulloides* d'Orbigny, Fossil Bluff; U.T.G.D. 84247, x 75; (0.37 mm); from U.T.G.D. 84015.
FIG. 25. - *Bolivina retiformis* Cushman, Marrawah; U.T.G.D. 84258, x 70; (0.40 mm); from U.T.G.D. 84104.
FIG. 26. - *B.* sp. C, Cape Grim; U.T.G.D. 84260, x 80; (0.36 mm); from U.T.G.D. 84002.
FIG. 27. - *B. finlayi* Chapman, Fossil Bluff; U.T.G.D. 84507, x 55; (0.48 mm); from U.T.G.D. 84024.

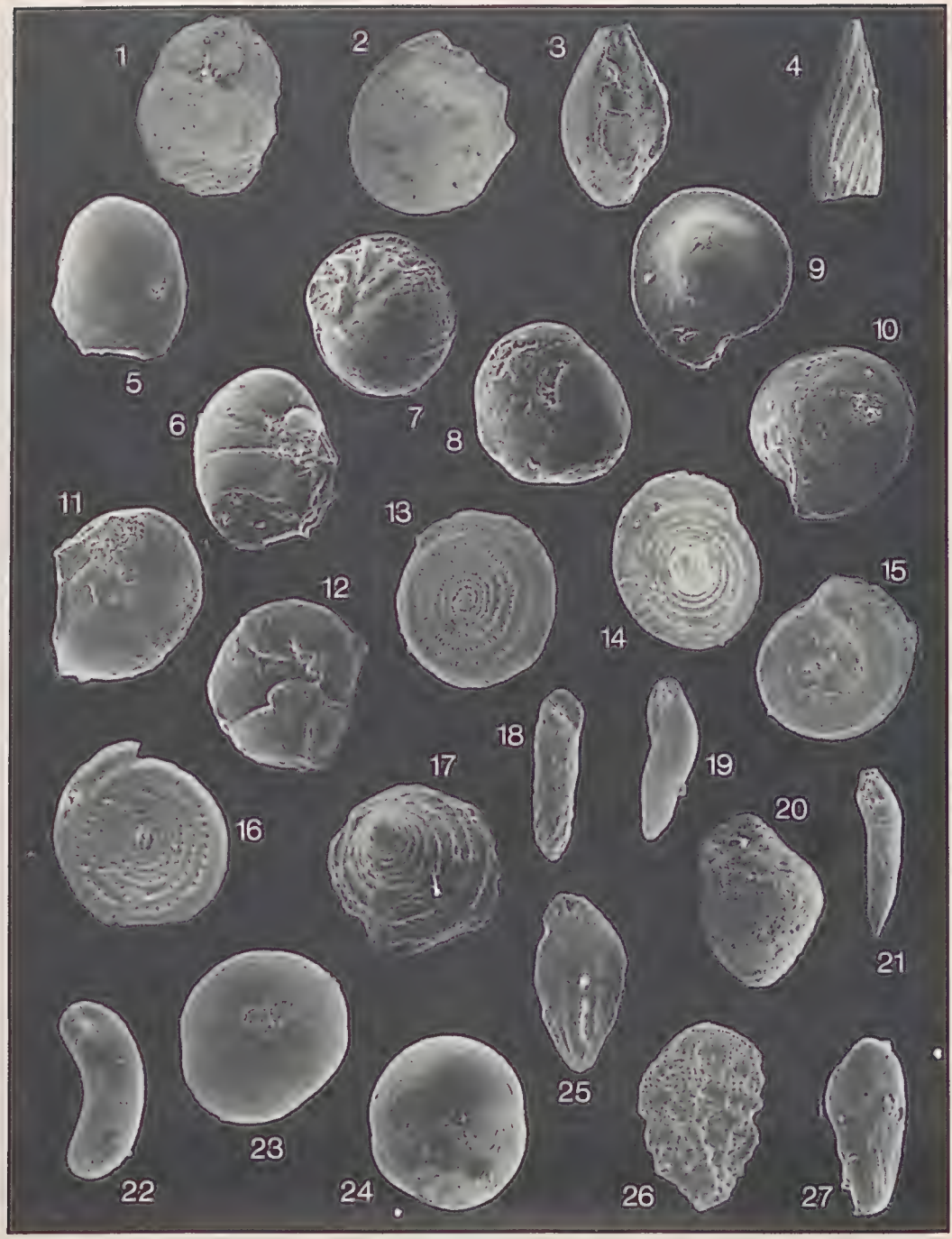

PLATE 1

PLATE 2

Figure in parentheses is maximum dimension of figured specimen

FIG. 1. - *Bolivina victoriana* Cushman, Fossil Bluff; U.T.G.D. 84259, x 50; (0.55 mm); from U.T.G.D. 84025a.
FIG. 2. - *B.* sp. A., Marrawah; U.T.G.D. 84493, x 50; (0.55 mm); from U.T.G.D. 84104.
FIG. 3. - *B.* sp. B, Fossil Bluff; U.T.G.D. 84494, x 150; (0.18 mm); from U.T.G.D. 840 84017.
FIG. 4. - *?Laterostomella* sp., Fossil Bluff; U.T.G.D. 84248, x 70; (0.40 mm); from U.T.G.D. 84013.
FIG. 5. - *Reussella ensiformis* (Chapman), Cape Grim; U.T.G.D. 84440, x 75; (0.37 mm); from U.T.G.D. 84002.
FIG. 6. - *R.* n. sp. Marrawah; U.T.G.D. 84441, x 45; (0.60 mm); from U.T.G.D. 84114.
FIG. 7. - *R. spinulosa* (Reuss), Cape Grim; U.T.G.D. 84444, x 70; (0.37 mm); from U.T.G.D. 84008.
FIG. 8. - *Tubulogenerina mooraboolensis* Cushman, Fossil Bluff; U.T.G.D. 84466, x 80; (0.30 mm); from U.T.G.D. 84013.
FIG. 9, 10. - Buliminid *incertae sedis*, Mussel Roe Bay; U.T.G.D. 84492, x 50; (0.55 mm); from U.T.G.D. 84481.
FIG. 11. - *Angulogerina australis* (Heron-Allen and Earland), Mussel Roe Bay; U.T.G.D. 84495, x 70; (0.40 mm); from U.T.G.D. 84481.
FIG. 12. - *Euuvigerina semiteres* (Vella), Marrawah; U.T.G.D. 84468, x 50; (0.54 mm); from U.T.G.D. 84104.
FIG. 13. - *E.* sp., Cape Grim; U.T.G.D. 84469, x 85; (0.30 mm); from U.T.G.D. 84008.
FIG. 14. - *E. schwageri* (Brady), Marrawah; U.T.G.D. 84565, x 30; (0.45 mm); from U.T.G.D. 84561.
FIG. 15 - *E. euteres* (Vella), Marrawah; U.T.G.D. 84467, x 50; (0.54 mm); from U.T.G.D. 84105.
FIG. 16. - *Siphogenerina canariensis* (d'Orbigny), Fossil Bluff; U.T.G.D. 84454, x 40; (0.65 mm); from U.T.G.D. 84011.
FIG. 17. - *S.* sp. cf. *S. moorei* (Vella), Marrawah; U.T.G.D. 84564, x 65; (0.45 mm); from U.T.G.D. 84561.
FIG. 18. - *Trifarina bradyi* Cushman, Fossil Bluff; U.T.G.D. 84465, x 55; (0.44 mm); from U.T.G.D. 84010a.
FIG. 19, 20. - *Buccella frigida* (Cushman), Cape Grim; U.T.G.D. 84261, x 75; (0.38 mm); from U.T.G.D. 84006.
FIG. 21, 22. - *B. lotella* Hornibrook, Marrawah; U.T.G.D. 84262, x 65; (0.42 mm); from U.T.G.D. 84113.
FIG. 23-25. - *Discorbinella araucana* (d'Orbigny), Mussel Roe Bay; U.T.G.D. 84296, x 100; (0.27 mm); from U.T.G.D. 84483.
FIG. 26, 27. - *D. bertheloti* (d'Orbigny), Fossil Bluff; U.T.G.D. 84298, x 55; (0.50 mm); from U.T.G.D. 84011.

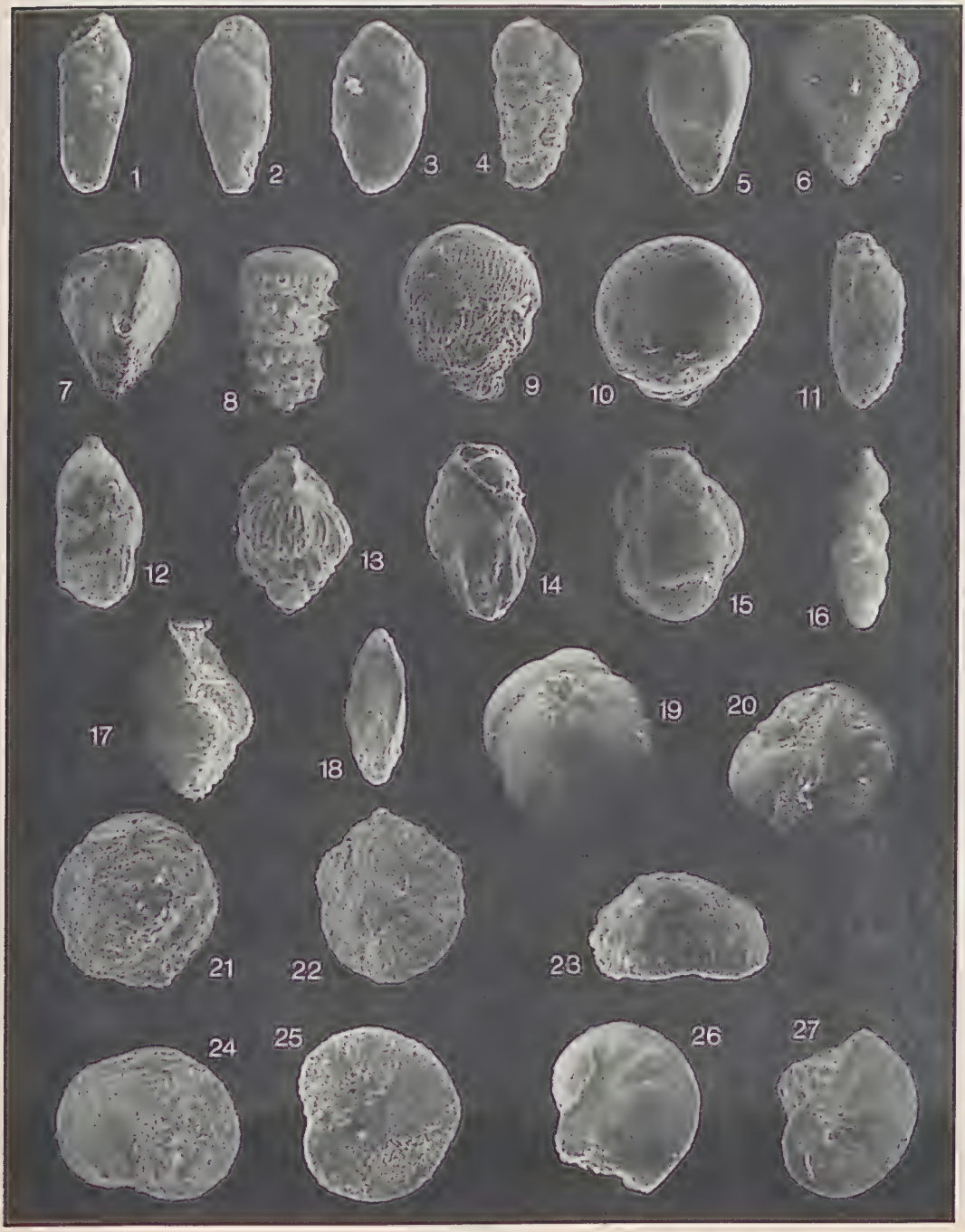

PLATE 2

PLATE 3

Figure in parentheses is maximum dimension of figured specimen

FIG. 1, 2. - *Discorbinella bertheloti* (d'Orbigny), Fossil Bluff; U.T.G.D. 84299, x 80; (0.34 mm); from U.T.G.D. 84015.
FIG. 3, 4. - *D.* sp. cf. *D. bertheloti*, Mt. Cameron West; U.T.G.D. 84297, x 70; (0.40 mm); from U.T.G.D. 84120.
FIG. 5-8, 11-13. - *Discorbis balcombensis* Chapman, Parr and Collins, 5, 6. Cape Grim; U.T.G.D. 84300, x 45; (0.65 mm); from U.T.G.D. 84008. 7, 8 Mussel Roe Bay; U.T.G.D. 84496, x 65; (0.47 mm); from U.T.G.D. 84481. 11-13 Cape Grim; U.T.G.D. 84313, x 45; (0.60 mm); from U.T.G.D. 84008.
FIG. 9, 10. - *D. barkeri* Mohan and Bhatt, Mussel Roe Bay; U.T.G.D. 84497, x 30; (0.80 mm); from U.T.G.D. 84481.
FIG. 14-16. - *Epistominella iota* Hornibrook, Brittons Swamp; U.T.G.D. 84532, x 90; (0.29 mm); from U.T.G.D. 84480.
FIG. 17-19. - *E. shauni* Quilty n. sp., Fossil Bluff; Holotype U.T.G.D. 84463, x 75; (0.35 mm); from U.T.G.D. 84011.
FIG. 20, 21. - *Svratkina australiensis* (Chapman, Parr and Collins), Marrawah; U.T.G.D. 84567, x 80; (0.32 mm); from U.T.G.D. 84561.
FIG. 22, 23. - *Gavelinopsis pukeuriensis* Hornibrook, Mussel Roe Bay; U.T.G.D. 84344, x 75; (0.36 mm); from U.T.G.D. 84481.
FIG. 24, 25. - *Laticarinina altocamerata* (Heron-Allen and Earland), Cape Grim; U.T.G.D. 84399, x 85; (0.35 mm); from U.T.G.D. 84408.
FIG. 26, 27. - *Planodiscorbis macropora* Carter, Marrawah; U.T.G.D. 84566, x 100; (0.30 mm); from U.T.G.D. 84561.
FIG. 28. - *Planulinoides biconcavus* (Jones and Parker), Marrawah; U.T.G.D. 84425, x 105; (0.26 mm); from U.T.G.D. 84104.

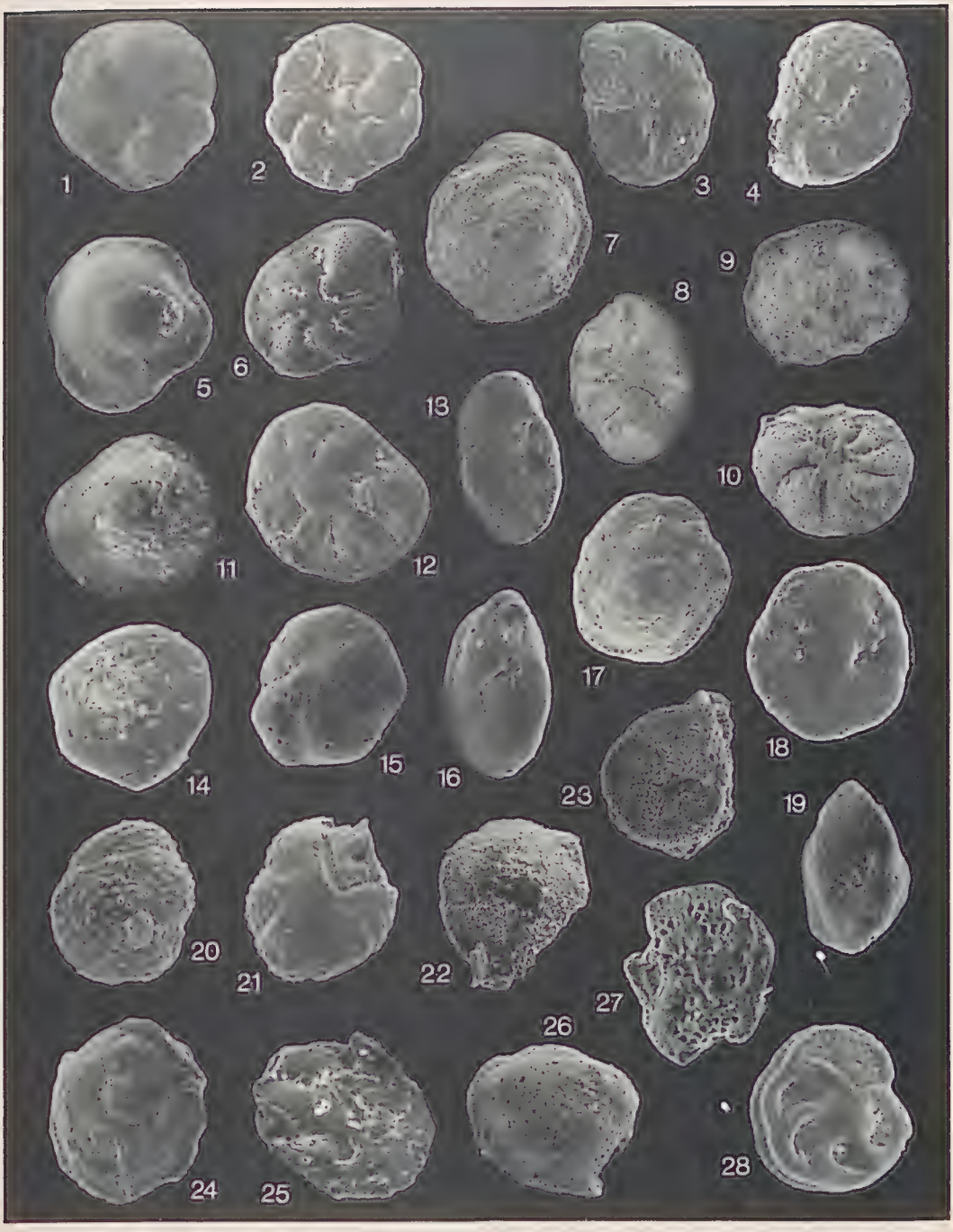

PLATE 3

PLATE 4

Figure in parentheses is maximum dimension of figured specimen

FIG. 1, 2. - *Rosalina turbinata* (Terquem), Marrawah; U.T.G.D. 84446, x 85; (0.31 mm); from U.T.G.D. 84104.

FIG. 3-6. - *R. terquemi* (Rzehak), 3, 4 Mussel Roe Bay; U.T.G.D. 84499, x 50; (0.55 mm); from U.T.G.D. 84481. 5, 6 Brittons Swamp; U.T.G.D. 84500, x 150; (0.20 mm); from U.T.G.D. 84480.

FIG. 7, 8. - *R. turbinata* (Terquem), Mussel Roe Bay; U.T.G.D. 84445, x 65; (0.42 mm); from U.T.G.D. 84482.

FIG. 9, 10. - *R. mitchelli* Carter, Cape Grim, U.T.G.D. 84447, x 40; (0.70 mm); from U.T.G.D. 84408.

FIG. 11, 12. - *R. vilardeboana* d'Orbigny, Marrawah, U.T.G.D. 84568, x 80; (0.20 mm); from U.T.G.D. 84561.

FIG. 13, 14. - *R.* sp., Cape Grim; U.T.G.D. 84448, x 130; (0.35 mm); from U.T.G.D. 84006.

FIG. 15, 16. - *Baggina* sp. cf. *B. philippinensis* (Cushman), Cape Grim; U.T.G.D. 84257, x 105; (0.37 mm); from U.T.G.D. 84005.

FIG. 17, 18. - *Cancris intermedius* Cushman and Todd, Fossil Bluff; U.T.G.D. 84265, x 60; (0.45 mm); from U.T.G.D. 84019.

FIG. 19, 20. - *C. laevinflatus* Hornibrook, Fossil Bluff; U.T.G.D. 84266, x 105; (0.25 mm); from U.T.G.D. 84011

FIG. 21, 22. - *Valvulineria* sp., Fossil Bluff; U.T.G.D. 84471, x 75; (0.37 mm); from U.T.G.D. 84011.

FIG. 23-25. - *Angulodiscorbis ludbrookae* Quilty, n. sp., Fossil Bluff; 23, 24. Holotype, U.T.G.D. 84355; (0.26 mm); from U.T.G.D. 84010b; 23. x 130, 24. x 105. 25. Paratype, U.T.G.D. 84357, x 100; (0.25 mm); from U.T.G.D. 84010b.

FIG. 26, 27. - *A.* sp. 2, Mussel Roe Bay; U.T.G.D. 84501, 26. x 140, 27. x 110; (0.25 mm); from U.T.G.D. 84482.

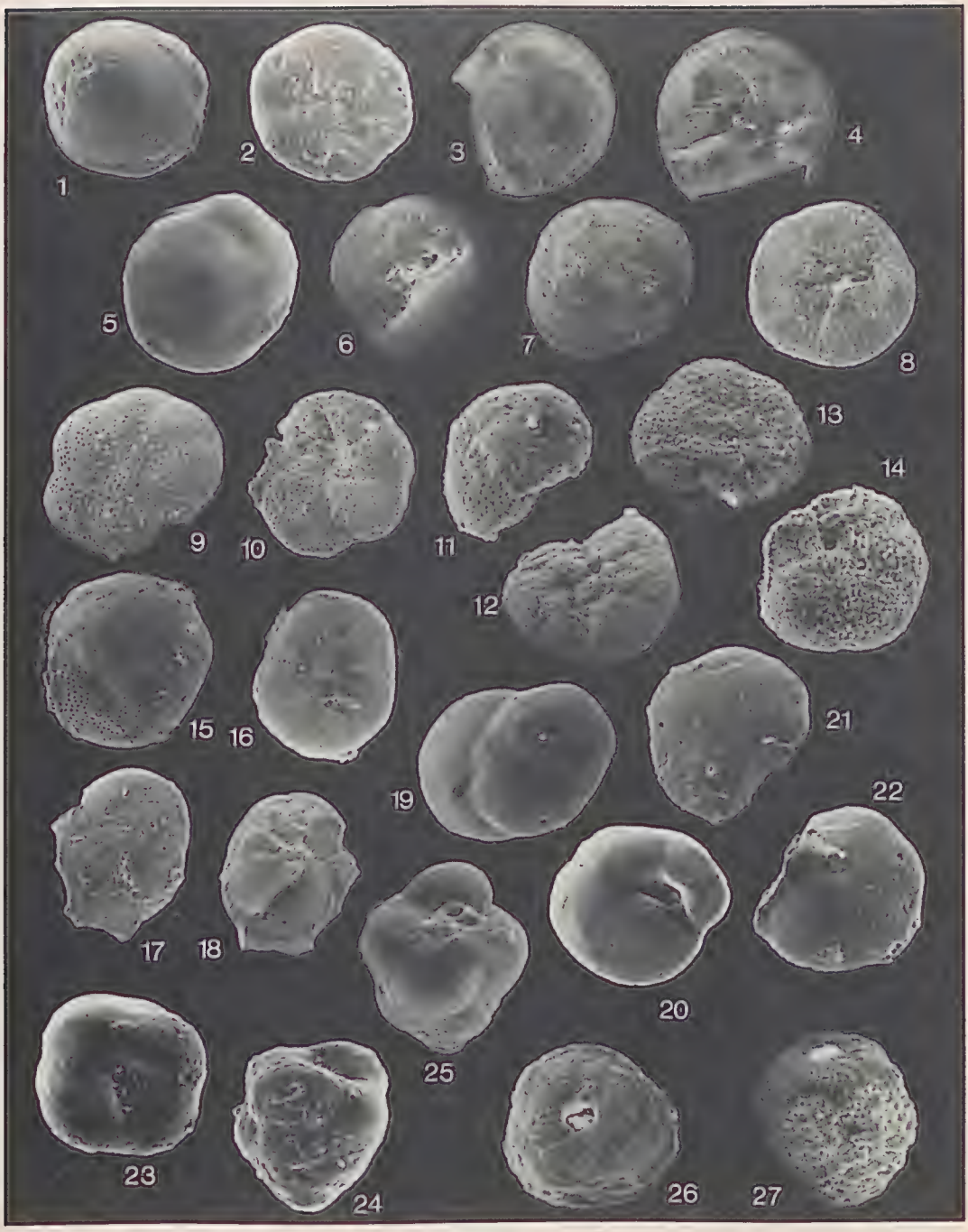

PLATE 4

PLATE 5

Figure in parentheses is maximum dimension of figured specimen

FIG. 1, 2. - *Bueningia creeki* Finlay, Mussel Roe Bay; U.T.G.D. 84502, x 125; (0.23 mm); from U.T.G.D. 84483.
FIG. 3, 4. - *Glabratella crassa* Dorreen, Cape Grim; U.T.G.D. 84345, x 65; (0.40 mm); from U.T.G.D. 84408.
FIG. 5, 6. - *G. cruciformis* (Howchin), Fossil Bluff, U.T.G.D. 84346, x 75; (0.37 mm); from U.T.G.D. 84010a.
FIG. 7, 8. - *G. globigeriniformis* (Heron-Allen and Earland), Cape Grim; U.T.G.D. 84347, x 70; (0.36 mm); from U.T.G.D. 84005.
FIG. 9, 10. - *G.* spl. 1, Fossil Bluff; U.T.G.D. 84348, x 110; (0.23 mm); from U.T.G.D. 84012.
FIG. 11, 12. - *G.* sp. 2, King Island; U.T.G.D. 84349, x 75; (0.40 mm); from U.T.G.D. 84084.
FIG. 13, 14. - *Heronallenia lingulata* (Burrows and Holland), Cape Grim; U.T.G.D. 84367, x 65; (0.42 mm); from U.T.G.D. 84001.
FIG. 15, 16. - *H. parri* Carter, Fossil Bluff; U.T.G.D. 84503, x 105; (0.25 mm) from U.T.G.D. 84011.
FIG. 17. - *Pileolina australensis* (Heron-Allen and Earland), Cape Grim; U.T.G.D. 84409, x 110; (0.26 mm); from U.T.G.D. 84008.
FIG. 18, 19. - *P.* sp. cf. *P. opercularis* (d'Orbigny), Cape Grim; U.T.G.D. 84410, x 60; (0.49 mm); from U.T.G.D. 84008.
FIG. 20-23. - *P. patelliformis* (Brady), 20, 21, Cape Grim; U.T.G.D. 84411, x 130; (0.22 mm); from U.T.G.D. 84008. 22, 23. Fossil Bluff; U.T.G.D. 84418, x 85; (0.33 mm); from U.T.G.D. 84010b.
FIG. 24, 25. - *P. zealandica* Vella, Mussel Roe Bay; U.T.G.D. 84301, x 60; (0.42 mm); from U.T.G.D. 84483.
FIG. 26, 27. - *P.* sp., Marrawah; U.T.G.D. 84419, x 70; (0.39 mm); from U.T.G.D. 84104.

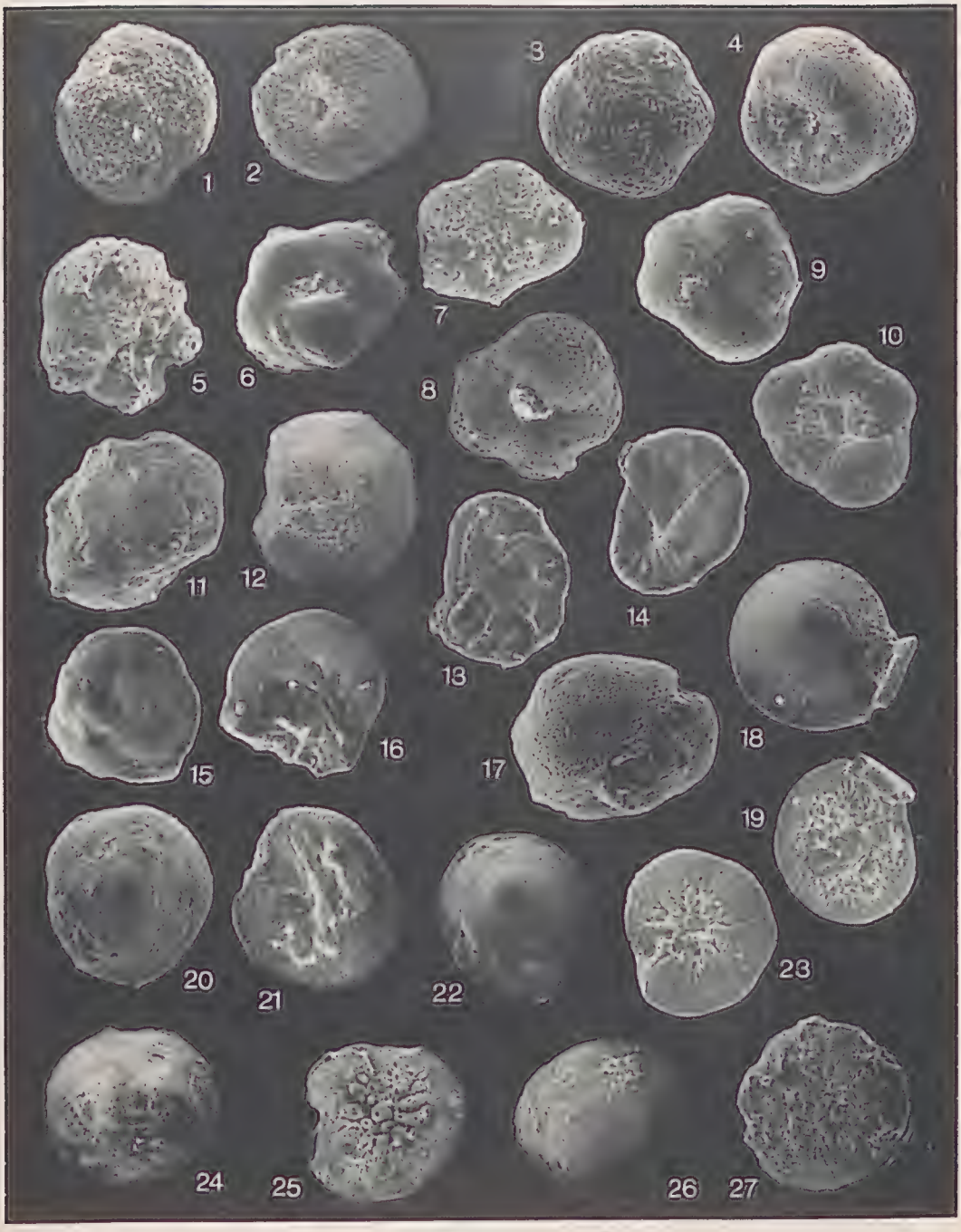

PLATE 5

Papers and Proceedings of the Royal Society of Tasmania, Volume 111, 1977.

(ms. received 5.1.1977)

OBSERVATIONS ON SOME TASMANIAN FISHES: PART XXIII

by E.O.G. Scott
Launceston

(with six tables and three text-figures)

ABSTRACT

CARCHARHINIDAE. *Carcharhinus greyi greyi*, second recorded specimen from Tasmania (first recorded as *C. brachyurus*); head in plan, mouth parabolic curves, orthogonal polynomials fitted; girth of head an exponential function of length from snout tip; notes on dentition, coloration; key to Tasmanian carcharhinids.
SPHYRNIDAE. *Sphyrna zygaena*, second recorded Tasmanian example, female, compared with first, male; logarithmic lengths to seven morphological landmarks yield a linear graph when plotted on logarithms of seven natural numbers (similar formulations in other sharks).
SYNGNATHIDAE. *Syngnathus phillipi*, study of two samples (meristic and morphometric data, variation within and between samples, supposed sexual dimorphism, pouch, coloration, depth range): *Syngnathus caretta* (apparently known only from type-specimens) reported from Tasmania; current knowledge of species extended: *Ichthyocampus runa* noted as a Tasmanian species: *Syngnathus poecilolaemus*, metrical data.
LAMPRIDAE. *Lampris regius*, new and old local records.
SCORPIDAE. *Scorpis aequipinnis*, morphometry and coloration in a juvenile sample; comparison with adult material, yielding data on regional relative growth.
LEPTOSCOPIDAE. *Crapatalus arenarius*, new subspecies described and figured.
TRIPTERYGIIDAE. General review of Tasmanian representatives, with key; *Tripterygium clarkei* (later placed in *Gillias* and *Norfolkia*) here referred to *Helcogramma*: specimen noted in R.M. Johnston's memoranda, identified as *T. clarkei* by Whitley, now described as a new species: *Gillias macleayana*, new material, table of dimensions: two new species of *Forsterygion* (New Zealand genus new to Australia) described and figured: *Brachynectes fasciatus* retained in that genus; size classes.
ECHENEIDAE. *Remora remora*, observations on two Tasmanian examples (host, Luth); outline of disc fitted with second degree polynomial; lengths of transverse ridges of disc an exponential function of their serial numbers; unusual white markings in one specimen.
SYNANCEJIDAE. *Glyptauchen insidiator mirandus*, habits; first detailed account of the subspecies; length-number patterns of spines and rays; taxonomic status discussed.

INTRODUCTION

This paper follows the general plan of others in the series. Linear measurements are given, unless otherwise specified, in millimetres, the name of the unit commonly being omitted. The symbols *Ls*, *Lt*, *TLs*, *TLt* denote standard length, total length, thousandths (permillages) of standard length, thousandths of total length, respectively. Standard deviation is regularly calculated with n degrees of freedom; derived statistics being computed from the value thus obtained. Registration numbers are those of the Queen Victoria Museum, Launceston. Certain other conventions are noted in earlier contributions.

Family CARCHARHINIDAE

In the five main Australian lists covering the elasmobranchs as a whole — the descriptive catalogue of Macleay (1882), the Check-list (McCulloch 1929), the Fishes of Australia, Part 1 (Whitley 1940), the Handbook (Munro 1956), the name-list of Whitley (1964) — this group has a varied history in respect of *(a)* name, appearing as

Carchariidae (Macleay) — this term of Regan's now used by most authors to denote a distinct family — Galeidae (McCulloch, Whitley 1940), Carcharhinidae (Munro); (*b*) scope of family, Macleay (only) including Sphyrnidae, Munro separating off Triakidae, Whitley separating off Triakidae and Galeorhinidae; (*c*) number of genera and species, the totals recognized being, in chronological order of sources cited, 5 and 11, 20 and 11, 24 and 13, 28 and 8, and (familial limits not specified) 38 or 41 and 19 or 20.

No species is accredited to Tasmania in any of these lists. However, a description, accompanied by a figure (lateral aspect, ventral surface of head, teeth) of a male carcharhinid, total length 2835 mm, length to origin of lower caudal lobe 2137, caught in the Tamar River, northern Tasmania, in 1897 and preserved as a mounted specimen in the collection of the Queen Victoria Museum (Reg. No. 962y) was given in Part V of these Observations (1942). The shark was there provisionally determined as *Carcharhinus brachyurus* (Günther, 1870) with *Galeolamna greyi* Owen, 1853 as a queried synonym: it was noted, however, there was reason to suspect that Günther's type specimens may not have been conspecific, and it was remarked, not without justification, 'the systematics of this genus are in a parlous state.'

Günther's species appears in Macleay's catalogue, the locality cited being Port Jackson, but is dropped from the other Australian lists here considered; it is now commonly treated as endemic to New Zealand (Whitley 1940, 1968; Garrick and Schultz 1963).

Owen's species was translated into recent literature by Whitley, who examined the type material (upper and lower jaws, from South Australia) in the Museum of the Royal College of Surgeons, and later (1940) identified as *Galeolamna greyi* the cocktail shark listed for South Australia by Waite (1923, p.27 and fig.) as *Carcharhinus brachyurus* (Günther, 1870), at the same time providing outline sketches of upper and lower teeth of the type specimen. As the outcome of further investigations in the field in Western Australia, he came to recognize three subspecies, the nominate subspecies, *G. greyi greyi* (from South Australia to Bunbury), *G. g. mckaili* (Swan river), *G. g. cauta* (Shark's Bay to Point Cloates): the last-named is among the forms investigated in the testing of a shark repellant by Whitley and Payne (1947). Illustrations of the first of these appear both in Whitley (1945, fig. 1) and in Whitley (1940, fig. 95, after Waite; fig. 88, no. 4), of the second in 1940 (fig. 303; fig. 88, no. 4; both as *G. greyi*), while the third is here first illustrated (fig. 2) — all three subspecies were subsequently given full specific rank (Whitley 1964), this elevation in status being admitted in the Handbook only in the case of *C. mckaili* ('bays and rivers, W.A.').

The identification of the South Australian whaler shark, or cocktail shark, as *Carcharhinus greyi greyi* is adopted in the Handbook, and is accepted by Scott *et al.* (1974), who note that in South Australia it is 'very common', being 'often seen by spearfishermen in comparatively shallow water'. This too is evidently an important, if not the prime, species of bronze whaler shark noted by Hancock (1976) as accounting for nearly one-third of the total commercial shark catch in Western Australia. The Tamar river specimen is thus now to be referred to Owen's, not, as in the first report of it in Part V, to Günther's species; and the recognition by Munro (1956) and by Scott *et al.* of an eastern subspecies is here conveniently followed.

Carcharhinus greyi greyi is distinguishable from another member of the genus, *C. macrurus* (Ramsay and Ogilby,1888), doubtfully recorded (Munro, Scott *et al.*) from South Australia, by its having anal origin slightly in advance of, instead of below, second dorsal origin, and by minor differences in dentition.

It may be remarked the Handbook gives the length of *C. g. greyi* as '4½ feet or more', while Scott *et al.* have 'to about 3 m'.

KEY TO CARCHARHINIDAE RECORDED FROM TASMANIA

1. Spiracle present (minute) slit-like. Precaudal pits absent. Caudal with secondary (posterior) lobe of upper lobe wide (giving 'double-tailed' appearance), its greatest width, measured normal to main axis of fin, > ½ (subequal to) oblique length of lower lobe. Anal origin well behind second dorsal origin..... *Galeorhinus australis*

   Spiracle absent. Precaudal pits present. Caudal with secondary (posterior) lobe of upper lobe small or moderate in width, its greatest width, measured normal to main axis of fin, < ½ (about 1/3) oblique length of lower lobe. Anal origin about below or in advance of second dorsal origin..... 2

2. First dorsal origin in advance of middle of length to caudal base; nearer to pectoral origin than to ventral origin. Longitudinal interval between first dorsal origin and ventral origin > interval between ventral origin and anal origin (extending about to, or beyond, anal termination). Pectoral not falciform, subtriangular, its greatest width ≥ ½ its length; the latter < length to origin of fin. Snout moderately rounded. Greyish above, lighter below ..... *Carcharhinus greyi greyi*

   First dorsal origin behind middle of length to caudal base; further from pectoral origin than from ventral origin. Longitudinal interval between first dorsal origin and ventral origin subequal to interval between ventral origin and anal origin. Pectoral strongly falciform, its greatest width < ½ its length; the latter ≥ length to origin of fin. Snout pointed. Brilliant blue above, white below.. *Prionace glauca*

Specific names adopted above are those used in the Handbook (Munro 1956). Whitley in 1940 listed the first as *Notogaleus australis* (Macleay, 1881) and in 1964 as *N. rhinophanes* (Péron, 1807) — genus *Notogaleus* Whitley, 1931; the second as *Galeolamna greyi* Owen, 1883 — genus *Galeolamna* Owen, 1883; the third in 1940 and 1964 as *Carcharhinus mackiei* (Phillipps, 1935), and later in 1968 as *Prionace mackiei*.

Genus *CARCHARHINUS* Blainville, 1816

Carcharhinus Blainville, 1816, *Bull. Soc. Philom.*, p.12. Type-species, *Carcharias melanopterus* Quoy and Gaimard, 1824. [Opinion 723, BZN, 22 (1), 1965: 184. Check-list (McCulloch 1929) gives logotype *Squalus commersonii* Blainville].
Carcharias Cuvier, 1816, RÈGNE ANIM., 1, p. 125. Type-species, *Squalus carcharias* Cuvier, 1816.
Galeolamna Owen, 1853, DESCR. CAT. OSTEOL. MUS. ROY. COLL. SURG., 1, p. 96. Type-species, *G. greyi* Owen, 1853.

Carcharhinus greyi greyi (Owen, 1853)

Galeolamna greyi Owen, 1853, DESCR. CAT. OSTEOL. MUS. ROY. COLL. SURG., 1, p. 96. Type locality: South Australia. (based on upper and lower jaws)
Carcharhinus brachyurus: Waite, 1923, FISH. S. AUST., p. 27, unnumbered fig. *Id.* Scott, 1942, *Pap. Proc. R. Soc. Tasm.* (1941), p.5, pl. 7. Not *Carcharias brachyurus*

Günther, 1870 (New Zealand only). Not *Carcharias brachyurus* Waite, 1906. Not *Carcharhinus brachyurus* McCulloch, 1919 (= *C. spenceri* Ogilby, 1910, *fide* Whitley, 1943, p. 119).

Galeolamna greyi: Whitley, 1932, *Rec. Aust. Mus.*, 18 (6), p. 324. *Id.* Whitley, 1940, FISH. AUST., 1, p. 100, fig. 95, fig. 88, no. 5: not *G. greyi, ibid* ., p.273, fig. 303 (= *G. mckaili* Whitley, 1945).

Galeolamna greyi greyi Whitley, 1945, *Aust. Zool.*, 11 (1), p.1, fig. 1.

Carcharhinus greyi greyi Munro, 1956, HANDBK FISH. AUST., 2, p. 9, fig. 59. *Id.* Scott, Glover and Southcott, 1974, MAR. FRESHW. FISH S. AUST., p. 36, 2 figs (fig. of animal = *C. brachyurus*: Waite, 1923).

Tasmanian occurrence. The first formal record, in 1942, for Tasmania based on a specimen caught in the Tamar river in 1897 has been noted above. An example stated to be 2.5 m in length and to weigh 160 kg was netted by Mr R. Wright, Launceston, at Greens Beach, northern Tasmania, on 23 January 1976. A report in the Launceston *Examiner* of 24 January (specimen misidentified as a white pointer) was accompanied by photographs of the dorsal aspect and of the mouth. The shark was buried but was exhumed on 25 January by Mr R.H. Green, Curator of Zoology, Queen Victoria Museum, who idendified it as a bronze whaler, and secured the caudal fin and most of the head for the Museum's collections (Reg. No. 1975/5/55). Though seldom coming under scientific observation, *Carcharhinus greyi greyi* is probably by no means uncommon in our waters. The writer has on various occasions received reports of its occurrence here; though it has not been practicable to confirm these, some of them, from fishermen with the South Australian catalogue of Scott (1962) or of Scott *et al.* (1974) available for reference, seem likely to be reliable. As noted above, the subspecies is abundant in South Australia and southern Western Australia.

Head, general. The head as preserved has been cut somewhat short, not including a gill-slit but embracing some gill tissue. Total length 320, length to front, back of mouth 160, 260, of nostril 81, 91, of eye 164, 197. Width of mouth 200; direct distance from nostril to mouth 88.5; from nostril to tip of snout 122.5; internarial 138. Interorbital 235. Nostril slightly oblique; its transverse length 30; anterior border of narial flap crenulate; cavity above tragus 17 (transversely) by 7.5.

Widths of whole head and of preoral head at tenths of anteroposterior lengths from tip of snout and width of mouth cleft at tenths of its fore-and-aft extension are noted in separate sections below. Maximum width of lower jaw 60. Depth at front, back of nostril 59, 67, front, back of mouth 130, 130; maximum depth (about 300 behind snout tip) 157.

Dorsal and ventral surfaces closely approaching each other externad, rendering the profile briefly rounded, tolerably sharp, ridge-like. Eye set right on profile, orbit extending on to lower surface. Abundant small, fairly closely set, irregularly disposed pores covering most of ventral surface, somewhat less numerous on mandible; a well defined arc of about 15-20 closely bordering either side of front of mouth, each pore set in the middle of a light-colored circle, the diameters of the circles sub-equal to their interspaces.

Head in plan. Snout 'long and pointed', 'bluntly rounded', 'moderately rounded','more broadly rounded than in preceding species' — such specifications conventionally appearing in specific diagnoses (the present examples are successive entries in the Handbook) clearly have some value; equally clearly their significance would be considerably enhanced by some measure of quantification. The following analysis of the form of the head, viewed in plan, is offered as an initial contribution to such specification. As preserved the present specimen does not include a gill slit; however, it does include some gill tissue, and with total length, 320, twice length to front of mouth, it can be regarded as being tolerably close to complete to level of first gill slit.

A tracing of the outline has been made, the anteroposterior axis marked off in

deciles, and widths measured at these levels. To introduce a measure of generalization the widths are given as proportional not as absolute dimensions, being expressed as a percentage of a convenient morphological unit. In view of the indeterminate nature of the dimension 'length of head', consequent upon the arbitrary level of severance, the unit here selected is width at level of front of mouth. In general, however, for the purpose of interspecific comparison widths would be more satisfactorily expressed as percentages of total length of head (to first or to last gill slit), thus making allowance for individual differences in mere size, without involving possible specific variation in form.

Orthogonal polynomials of the second and third degree have been fitted in accordance with the method perfected by Fisher (1932). With N = percentile number, counting caudad, W = width of head as percentage of width at front of mouth, the second degree equation is $W = 99.36 + 9.0242\ (N - 5.5) - 0.66295\ (N^2 - 11N + 22)$, *i.e.*, $W = 35.14 + 16.317\ N - 0.66295\ N^2$. Predicted values of W (actual values in parentheses) are 50.8 (46.6), 65.1 (66.9), 78.1 (82.2), 89.8 (92.5), 100.2 (100.0), 109.2 (105.9), 117.0 (114.5), 123.2 (122.0), 128.3 (128.8), 135.5 (133.9). The third degree equation, with the additional term $0.14015\ (N^3 - 16.5\ N^2 + 76.10\ N - 85.80)$, is $W = 23.11 + 26.986\ N - 2.9758\ N^2 + 0.14015\ N^3$; predicted values of W being 47.3, 66.3, 81.1, 93.0, 101.2, 108.2, 115.1, 120.3, 125.3, 135.5.

The reduction in sum of squares due to fitting the regression is a significant one at each stage, the ratio of the remainder, $S\ (Y - \tilde{Y})$ to the mean square for error yielding successively F = 178.62, 23.11, 14.48, (d.f. = 1 and 8, 7, 6). For the equation in N^2 the percentage of deviations of $\tilde{W}$ from W ranges from 0.2 to 9.0, mean 2.80; for the equation in N^3 from 0.2 to 2.7, mean 1.43. The formal significance of the third degree equation is highly satisfactory; the equating of the remaining sum of squares, 8.1364, to Sy^2, 7019.5, with $1\text{-}R^2$ yielding R = 0.99942.

The coefficient of N^2 in the second degree polynomial provides a direct measure of the pointedness of the curve; and hence in equations derived from strictly comparable data permits a quantitative comparison of the feature in two species.

For pragmatic taxonomic purposes a formulation leading to a straight line graph is in some respects more convenient than one involving a curvilinear graph, providing a more immediate visual estimation of parameters. An exponential treatment in the general form of $W = a \log N + b$, or $N = 10^{\frac{w-b}{a}}$ is discussed below (it has been considered expedient to work in common, rather than in natural, logarithms). The chief disadvantage of the procedure with the present data lies in the fact that the graph presents a point of inflexion.

Plotting the 10 relative widths successively caudad on the integral numbers 1-10 along a logarithmic abscissa is found to yield very good approximations to two straight lines, the first (A) covering logs 1-6, the second (B), with a markedly steeper gradient, logs 7-10. Here, as in the preoral and the mouth curve graphs discussed later, the point of inflexion, as visually assessed, occurs at, or significantly close to, a plotted point, i.e., it effectively has as abscissal value a natural-number logarithm. This pair of coördinates can thus formally be treated as belonging to the first segment (the convention here adopted) or the second or to both (the last-mentioned procedure, by its provision of an additional degree of freedom, yielding increased statistical formal significance to each of the two graphs).

With N and W as before, the equation for the best-fitting straight line for (A) is $W = 77.49 \log N + 45.60$; $t = 37.255$***. Decile widths as calculated are 45.6, 68.9, 82.6, 92.1, 99.8, 105.9. For (B) the equation is $W = 126.74 \log N + 74.47$; $t = 51.219$***: decile values are 114.6, 121.9, 128.4, 134.2.

For (A) the percentage deviation of predicted from measured values is 0.03-3.0, $\bar{x}$ 1.27; for (B) 0.08-0.3, $\bar{x}$ 0.19, the noticeably greater mean of (A) deriving largely from the contributions (2.1, 3.0) made by the first two entries. A composite character of (A) is thus suggested (in the traced outline of the head a decrease in rate of curvature is apparent near the level of the nostrils, at about the middle of the preoral length.) When deciles of preoral width are plotted on the integral logarithms 1-10, the graph is seen to run, with significant rectilinearity, from log 1 to log 3 (Aa) and to continue, with steeper slope, from log 4 to log 10 (Ab).

With w = relative width, n = preoral decile number, the regression equation for (Aa) is w = 63.09 log n + 27.60 ; t = 373.739***: measured (calculated) decile percentages are 27.5 (27.6), 46.6 (46.6), 57.6 (57.7). For (Ab) w = 83.05 log n + 17.49 ; t = 64.090***; deciles 66.9 (67.5), 75.8 (75.5), 82.2 (82.1), 88.1 (87.5), 92.8 (92.5), 96.6 (96.7), 100.0 (100.5). Percentage deviations of $\tilde{w}$ from w are for (Aa) 0.02-0.2, $\bar{x}$ 0.11, for (Ab) 0.1-0.8, $\bar{x}$ 0.47.

Four equations have been set out above, (A) = {N = 1-6} , (B) = {N = 7-10} , (Aa) = {n = 1-3} , (Ab) = {n = 4-10} . However, in the present specimen {N = 5} is located (adventitiously, as result of abitrary level of severance) at level of front of mouth. We can therefore calculate the postoral portion of the combined (A) and (B) graphs as B_1 {N = 6-10} , the equation (naturally closely similar to that for (B) = {N = 7-10}) being W_1 = 127.40 log N + 6.85 ; t = 104.178: predicted values of W_1 106.0, 114.5, 121.9, 128.4, 134.5, the percentage deviation of these from actual values (given above) being 0.06-0.4, $\bar{x}$ 1.20. Thus in this particular example the form of the head in plan is completely specifiable from the available data, on the basis of the present ad hoc mode of specification, by three equations only, (Aa), (Ab), (B_1), representing three exponential arcs, the first accounting for approximately the anterior one-fourth, the last for the posterior one-third of the length.

It is of interest to note that the goodness of fit obtained in this ad hoc procedure is well above that afforded by the third degree polynomial, the percentage deviation of predicted from actual values being in the former 0.02-0.8, $\bar{x}$ 0.31, in the latter 0.2-2.7, $\bar{x}$ 1.43 — however, the present method has of course the disadvantage of treating the overall curve as three component curves.

Mouth. The anterior border of the crescentic mouth lies behind tip of snout by 1.60 its anteroposterior extension, the latter being just half the chord at the angle of the mouth, or 1.13 direct distance from mouth to nostril. A small, rather widely divergent labial groove is present, its length (12.5 mm) 0.06 width of mouth, equal to direct distance from its tip to mouth cleft.

The curvature of the mouth cleft in sharks varies markedly between, but is in general tolerably uniform within, families; the length of the gape ranging from less than one-third of its width in scyliorhinids to more than twice as much in sphyrnids, the feature doubtless being correlated with feeding habits. In the present specimen the length-width ratio is 0.50; judging from published figures it ranges among carcharhinids from near that value to rather more than 0.6.

The mouth cleft has been examined by the methods employed in the analysis of the curve of head in plan, widths being measured at tenths of the anteroposterior length, and being generalized by being expressed as percentages of chord of mouth at angle.

The N^2 equation is W = 71.60 + 7.5151 N − 0.53220 (N^2 − 11N + 22), i.e. W = 18.56 + 13.369 N − 0.53220 N^2. Predicted values (actual in parentheses) are 31.5 (30.5), 43.2 (44.0), 53.9 (53.0), 63.5 (65.5), 72.1 (72.5), 79.6 (79.0), 86.1 (85.5), 90.5 (90.5), 95.8 (95.5), 99.0 (100.0). The third degree equation, with the additional term 0.36425 (N^3 − 16.5 N^2 +76.10 N − 85.80), is W = 15.43 + 16.14 N − 1.1331 N^2 + 0.036425 N^3; predicted values of W being 30.5, 43.5, 55.8, 64.2, 72.4, 79.4, 85.4, 90.7, 100.0. Note that the equation in N^3 passes through the first and the last two points

of the series.

As with the equations for head in plan, the reduction in sum of squares due to fitting is significant at all stages, with F, as before, 23.60, 195.61, 178.82. For the equation in N^2 the percentage deviations of $\widetilde{W}$ from W range from 0.0 to 3.0, mean 0.72. At the conclusion of the fitting of the third degree term the multiple correlation coefficient R has the highly satisfactory value of 0.99986.

For the ad hoc procedure involving an exponential formulation and yielding a rectilinear graph with one point of inflexion the equation for (A) = {N = 1-3} is W = 46.91 log N + 30.73 ;t = 28.491*; decile chords as calculated 30.3, 44.5, 52.5. For (B) = {N = 4-10} W = 87.43 log N + 11.86 ;t = 53.047***; deciles 64.5, 73.0, 79.9, 85.7, 90.8, 95.1, 99.3.

The variation of predicted from measured value in (A) is 0.6-1.0,$\bar{x}$ 0.83%; in (B) 0.3-1.5,$\bar{x}$ 0.72% — values seen not to differ greatly from those for the polynomials.

Comparison of head and mouth curves. Even the most casual observer, it would seem, could not fail to be struck by the visually pleasing relationship between the curve of the mouth and that of the head as a whole: and since the appearance of *On Growth and Form* (Thompson 1942) biologists have learnt to expect that many instances of natural aesthetic elegance are susceptible of precise mathematical specification. In the present case it has been shown both curves represent, to a good approximation, a parabola.

In the formulations already given the curve of the head has been calculated from decile widths expressed as percentages of width of head at level of front of mouth, while the corresponding morphological unit for specification of the mouth curve has been maximum width of mouth. To make possible a direct comparison of the parabolas for head and mouth, that for the latter is here calculated with deciles expressed as percentages of head width at front of mouth, the equation being W = 13.48 + 12.451 N − 0.55341 N^2; that for head W = 35.14 + 16.317 N − 0.66295 N^2. The numerically smaller negative value of the coefficient of the second-degree term in the equation for the mouth is indicative of the relevant curve being shallower than the curve of the head.

An interesting ad hoc comparison of the two curves, presented in the convenient form of a straight line graph (with a point of inflexion) is obtained by plotting successive cumulated deciles of head width. With all dimensions in mm the equation for deciles 1-3 is cum M = 0.5510 cum H + 0.73 ;t = 192.534***: for deciles 4-10 cum M = 0.6293 cum H — 4.45 ;t = 503.809***. Values predicted by these equations (measured values in parentheses): 61.3 (61), 148.1 (149), 255.2 (255), 383.9 (386), 532.6 (531), 689.9 (689), 859.8 (860), 1041.1 (1041), 1229.4 (1232), 1431.2 (1432).

Head, girth. The shape of the head (and of the body in advance of dorsal origin) viewed laterally is of taxonomic significance, especially the degree of gibbosity of the dorsal profile above and behind the gill slits. In the present specimen the overall anteroposterior convexity of the dorsal surface is slight or moderate: however, at 270 behind snout tip there occurs a low median swelling about 60 long and about 100 wide.

The girth of the head of the present specimen at 10 equal intervals, concluding at the furthest level back at which satisfactory measurement is feasible (300 mm from snout tip), has been determined.

It has been found the relation between girth, G, and decile number N (1, most anterior) is, to a significant approximation, of the form $G = bN^k$. Expressed in the convenient form log G = k log N + b, yielding a straight line graph, the equation (G in mm) is log G = 0.5166 log N + 2.3764 ;t = 18.187***. The 10 girths (with

predicted values in parentheses) are 231 (238), 348 (340), 420 (420), 502 (487), 551 (546), 600 (600), 645 (650), 696 (697), 793 (740), 761 (782).

Head, pores. Most of ventral surface liberally sprinkled with minute pores, in general from 1-2 to 3-4 mm apart; least numerous behind level of eyes and along internal border of lower jaw. A regular series of about a score of rather more conspicuous pores, each in middle of lighter colored spot, about 3 in diameter, bordering upper lip; about 30 scattered irregularly adjacent to these.

Head, color. Save for a subelliptical isabelline patch about 50 long, 45 wide, beginning 105 behind snout tip, dorsal surface almost uniform slate grey. Ventral surface mostly off-white, in places approaching ivory; somewhat dusky strip narrowly bordering upper jaw, width 10 at angle increasing to 25 just behind level of tip of lower jaw, in advance of this spreading out to form a semielliptical patch about 60 long, 100 wide; some duskiness (differing in extent and disposition on two sides) round about nostrils; from level of nostril backwards dark grey of dorsal surface extending briefly on to ventral surface, strip increasing to width of 10-12 at level of eyes, behind this progressively decreasing slightly.

Dentition. Teeth in upper jaw 16 and a small symphysial on each side; in anterior part of jaw disposed alternately in outer and inner rows, latter the even numbers, counting outwards; inner tooth set closely against two outer flanking it, from one-tenth to one-eighth of its base hidden by their bases. General form very similar to that of teeth of type as sketched by Whitley (1940, fig. 88, no. 4); subtriangular; border directed towards angle of mouth somewhat sinuate, the larger upper portion convex; other border slightly concave in upper half, curve below more rapid; both borders delicately serrate almost to tip; some stronger serrations on base. Between first main tooth on either side 2 small symphysial teeth; on level of inner series. Vertical height of 10 teeth from second on right, through two symphysial to sixth on left 9.0, 7.1, 4.9, 5.0, 6.5, 7.3, 10.4, 13.0, 15.4, 12.5 (measured from midpoint of exposed, slightly upwardly convex base), size thereafter continually decreasing; bases (visible) 8.6, 7.4, 5.5, 6.6, 8.8, 10.0, 11.1, 12.7, 14.0, 13.1; distance between tips 9.0, 5.7, 6.0, 8.6, 7.9, 9.0, 12.1, 10.3, 11.7. Median teeth nearly erect, others sloping progressively further outwards.

Teeth in lower jaw 16 (plus small symphysial tooth), on each side, not alternate, first three on either side, and symphysial, with a similar tooth directly behind it; smaller than those of upper jaw, decreasing in size from third, outermost 1-2 high; in general more symmetrical than upper teeth, laterally progressively approaching conical; microscopically serrate. Symphysial tooth with a very slightly larger tooth immediately behind it, with base contiguous with bases of inner pair of first teeth. Vertical height of 9 teeth from second on right, through symphysial, to sixth on left 7.0, 6.0, 2.2, 5.0, 6.9, 9.1, 9.9, 9.0, 7.1; bases (visible) 12.5, 8.5, 2.0, 8.1, 12.2, 9.1, 9.9, 9.0, 7.1; distance (dividers) between tips 10.7, 9.9, 5.2, 10.9, 10.9, 11.1, 11.0, 10.9. Anterior teeth leaning outward at about 40°, outer becoming increasingly nearer upright.

Caudal fin. The general form of the caudal is tolerably constant in Australian representatives of *Carcharhinus* — upper lobe subtriangular, superior border moderately convex, length about twice lower lobe, subequal to (usually somewhat exceeding) head; terminal secondary lobe rather small, its length 2-4 in length of rest of lobe.

Some dimensions (mm) of Greens Beach specimen. Length (direct, not following curve) of upper border 655; of other borders, in succession, 160, 65, 350, 160, 305. Depth (in parentheses, first, diameter of elevated strip over vertebral column, secondly, distance of strip from superior border) at origin 92 (60, 32), at upper end of hind border of lower lobe 190 (55, 73), at notch 58 (36, 16), at greatest depth of second lobe 109 (33, 24). Vertebral column ends 65 in advance of tip, 36 below superior

border, 20 above inferior. Borders, in succession as before, moderately convex with rate of curvature increasing caudad; slightly concave, especially in lower one-third; sigmoid; moderately convex, strongly crenulate; slightly concave, regularly crenulate; rather strongly convex.

Upper caudal lobe originating, 23 behind level of origin of lower lobe, as ridge arising from shortly behind middle of subtriangular depression, 25 long, 40 wide, depth 5, at middle of transverse anterior border, depth progressively decreasing backward. At base of lower caudal lobe a transverse bursa, 23 wide, 5 deep, the anterior wall a fleshy subvertical flap, readily apposable to hind wall closing whole pocket.

Above vertebral column virtually uniform dark grey, elsewhere in general lighter, ivory or flesh-colored. Borders, in succession as before, dark grey; a trifle lighter than light ground color; same; in posterior two-fifths marginally lighter for about 1 mm, rest with about 1 of white distally, followed by about 2 of near-black, followed by 2-3 obscurely dark or darkish; similar to anterior part of last border, but more obscurely marked, increasingly so towards tip of lobe; light, concolorous with remainder of lobe.

Family SPHYRNIDAE

As the outcome of a survey by the writer (1973) of Sphyrnidae reported in Australian waters, in all seven species, it was concluded that those satisfactorily recorded comprise *Sphyrna lewini* (Griffith and Smith, 1834), *S. zygaena* (Linné, 1758), *S. mokarran* (Rüppell, 1835) — with *S. ligo* Fraser-Brunner, 1950 as a probable synonym — with the inclusion of *S. blochii* (Cuvier, 1816) in doubt.

The Australian history of *S. zygaena*, an example of which is noted below, is a curious one, traced in detail in the paper cited. In summary: earlier writers not unnaturally recorded hammerheads under the familiar name of the European *S. zygaena* (or, as in Johnston's first Tasmanian catalogue (1883), as the synonymic *S. malleus* Valenciennes, 1822); as the description of *S. lewini* (type locality, 'South coast of New Holland') became more widely known there developed a tendency more or less automatically to report all Australian captures as this species, *S. zygaena* appearing with decreasing frequency in the local literature, and by 1934 (a hundred years after the description of *S. lewini*) virtually disappearing from it. With the publication in 1967 of Gilbert's revision of the hammerheads of the world the systematics of the family were first placed on a satisfactory basis. A hammerhead caught in George Bay, east coast, in 1970 has been shown by the writer (1973) to be *S. zygaena*. While it would appear probable that *S. lewini* occurs in Tasmanian waters, early records of it in local lists — *e.g.*, Lord (1923, 1927), Lord and Scott (1924) — must be regarded as suspect and in need of confirmation.

A key to the Australian species appears in the paper cited. *S. zygaena* and *S. lewini* are most readily distinguished by the outline curve of the anterior part of the head; viewed in plan, this presents in the former an unbroken forwardly convex sweep, while in the latter it includes a median concavity.

Genus *SPHYRNA* Rafinesque, 1810

Cestracion Klein *in* Walbawm, 1792, Type-species, *Squalus zygaena* Linné, 1758, by subsequent designation of Gill, 1861. Name inadmissible by International Commission rules, 1907, 1910.

Sphyrna Rafinesque, 1810, INDICE D'ITTOLOGIA SICILIANA, pp. 46, 60. Type-species, *Squalus zygaena* Linné, 1758, by subsequent designation of Jordan and Gilbert, 1883.

Sphyrna zygaena (Linné, 1758)

Squalus zygaena Linné, 1758, SYST. NAT., ed. 10, p.234. *Ex* Artedi. Type locality: Europe and America.

Sphyrna (Sphyrna) zygaena Scott, 1973, *Rec. Queen Vict. Mus.*, 48, p.3 (Australian synonymy and references).

Material. A young female specimen, 641 mm in total length, collected by Mr N. Blichfenot 30 km north of Bridport, north coast, in 50 m on 12 May 1976 (Q.V.M. Reg. No. 1976/5/149). A young male, 610 mm in total length, collected by Mr E. Gatenby in George Bay, east coast, on 17 April 1970 (Q.V.M. Reg. No. 1970/5/14), providing the first authentic Tasmanian record of this species, has been described and figured by the writer (1973). See also Part XIX (1974a, p.252).

Dimensions. The following set of dimensions, expressed as permillages of total length (between parallels) includes all items reported (1973, table 1) for the George Bay specimen, the values for the latter here being cited (in parentheses) for direct comparison.

Length to first gill slit 176 (162), to fifth 231 (220). Mouth: length to upper lip 65 (61), to angle 112 (109), to mandibular symphysis 70 (66); width of cleft 73 (63), width at labial folds 76 (67). Width, depth of head at: midpoint of scallops 109 (98), 28 (21), tips preocular prominences 256 (233), 37 (36), first gill slit 86 (95), 90 (74), fifth gill slit 89 (74), 92 (85); maximum 287 (259), 94 (85). Eye: length to, parallels, 72 (62), direct from snout tip 153 (138); horizontal diameter 20 (24), vertical 18 (21). Orbit: horizontal diameter 22 (26), vertical 19 (22). Interorbital 271 (248). Nostril: length to, parallels 53 (49), direct from snout tip 120 (106); distance from eye 16 (16), from orbit 12 (15). Internarial 212 (190). Inner narial groove: length (chord) 65 (56); distance from anterior end direct to snout tip (profile) 62 (54); distance between anterior ends of grooves 103 (101). Length of second (largest) gill slit 21 (22), of fifth 17 (17).

First dorsal: length to origin 288 (266); base 85 (90); length of anterior border 148 (139), of distal 108 (82), of lower border of lobe 31 (26); vertical height 109 (103). Interdorsal 257 (248). Second dorsal: length to origin 628 (603); base 31 (30); length of anterior border 37 (31), of distal (41),48 (41), of lower border of lobe 41 (44); vertical height 23 (16). Anal: length to origin 593 (577); base 38 (43); length of anterior border 54 (44), of distal 37 (38), of upper border of lobe 41 (37); vertical height 27 (21). Pectoral: length to origin 218 (213); [this measurement is to level of origin of anterior border; length to girdle, felt immediately below surface, 209, (203)]; base 58 (49); length of anterior border 120 (113), of distal 89 (75), of posterior 34 (38); total length 125 (125); maximum width normal to longitudinal axis 75 (69: in table 1 (1973), in error, 110). Interpectoral: at anterior end of base 69 (62), at posterior end 30 (30). Pelvic: length to origin 477 (457); base 36 (40); length of anterior border 37 (41), of distal 51 (44), of posterior, total 34 (35), free 25 (20); total length 76 (69); maximum width normal to longitudinal axis 38 (39). Interpelvic: at anterior end of base 39 (30), at posterior end 25 (15).

Upper lobe of caudal: length to origin (at precaudal pit) 727 (711); base ('precaudal pit to junction with lower lobe' = to junction of hinder border of subtriangular lower lobe with anterior end of linear section of inferior border) 89 (81); length of anterior border 287 (289), of posterior below notch 193 (193); terminal lobe, anterior border 24 (20), posterior 48 (40); width at notch 24 (21). Lower lobe of caudal: length to origin 718 (692); base (slightly oblique) 72 (67); length of anterior border 114 (107), of posterior 64 (55). Length to end of vertebral column 988 (982). Length to vent (middle) 518 (474). Depth (width) at: first dorsal origin 101 (95), 80 (72), pelvic origin 86 (79), 72 (56), anal origin 59 (57), 41 (41); caudal peduncle (minimum) 41 (39), 34 (30); maximum (body) 109 (97), 78 (74).

It will be seen the relative dimensions recorded are in general in tolerably close agreement; there being no clear indication of sex differentiation.

Metrical characters of key. Specifications of *S. zygaena* and *S. lewini* in the key to Australian species include three metrical items. *(i)* Inner narial groove extending in *S. zygaena* ≥ ½, in *S. lewini* < ½ (*ca* 0.4-0.45), distance from anterior end of groove direct to snout tip: in both the earlier (male) and present (female) specimen the value is 0.51. *(ii)* Distance from naris to orbit in *S. zygaena* < (*ca* ½), in *S. lewini ca*, diameter of eye: in the male this is 0.71, in the female 0.63. *(iii)* Lobe of second dorsal extending in *S. zygaena* < 2/3, in *S. lewini* > 2/3 (*ca* 3/4-4/5) distance from fin base to precaudal pit: in the male the extension is 0.56, in the female 0.60.

Coloration. The overall coloration, slaty grey above, lighter, whitish or approaching whitish below, is similar to, but somewhat lighter than, that of the juvenile male, other references to which are here made in parentheses. Strip of white encroaching from ventral surface on to dark grey along anterior border of head about 2 mm (about 1 mm) wide, expanding on preocular prominences into ovoid whitish patches (not developed). Anterior borders of dorsals narrowly margined (as in male) with darker. Anal mostly whitish or faintly dusky, concolorous with ventral surface of body, deeply dusky round junction of anterior and distal borders, pure white along lower border of lobe (transverse dark markings in male lacking). The curious dark markings on the side behind pelvic origin, in the form of splashes and downwardly and forwardly oblique dark bars described and figured in the male occur also in the present specimen, all here being bars. On the left side, where they are somewhat better developed, they comprise, in sequence caudad, three short, above pelvic base; two fairly close set, about 30 by 2-3 mm, about 20 by 2, first partly above pelvic base; one short midway between dorsal and ventral profiles, above anal base; two dark and conspicuous, about 40 by 3, about 35 by 5-8, extending over two-thirds of height above lobe of anal; three, narrow, short, closely set in hind half of caudal peduncle.

Mouth. As noted above the curvature of the mouth is more shallow in carcharinids than in sphyrnids; the length/width ratio, 0.50 in our example of *Carcharhinus greyi* here being 0.65. An equation has been calculated for the curve obtained by placing a card in the mouth and tracing the outline of the lower jaw; 10 measurements of width then being taken at equal intervals. With N = decile number, counting caudad, $W = 10.92 + 5.127\ N - 0.1539\ N^2$; actual values of W (calculated in parentheses) 15.0 (15.9), 21.5 (20.6), 24.5 (24.9), 30.0 (28.9), 33.0 (32.7), 35.5 (36.1), 38.5 (39.1), 41.5 (42.0), 44.5 (44.4), 47.0 (47.6). To permit of direct comparison with specimens of other sizes the parabola has been recalculated with Wm = width as percentage of maximum width of curve: $Wm = 27.17 + 10.20\ N - 0.3337\ N^2$.

Location of certain morphological landmarks. It is found that when the logarithms of the lengths from snout tip to certain notable morphological points are plotted against the logarithms of certain natural numbers within the range 1-10, the resultant graph is significantly linear. With L = length, mm, to one of the seven-member set { back of mouth, pectoral origin, first dorsal origin, pelvic origin, anal origin, caudal origin (taken as origin of upper lobe), total length }, N = relevant natural number of set { 2, 3, 4, 5, 6, 7, 8, 10 }, the equation of the best straight line for the present specimen is $\log L = 1.3313 \log N + 1.4668$; $t = 54.523$; measured (predicted) values of L 72 (74), 134 (127), 183.5 (185), 306 (318), 390 (391), 461 (466), 641 (628). For the specimen reported in 1973 the corresponding equation (with L as thousandths of total length, not mm) is $\log L = 1.3466 \log N + 1.6322$; $t = 40.105$; measured (predicted) values of L 109 (109), 203 (187), 260 (278), 457 (479), 577 (589), 711 (705), 1000 (952). In both cases length to pectoral origin is measured to felt-for girdle just below the integument; the value previously reported for the male (1973, table 1) is length to origin of (external) anterior border of fin. In this shark anal origin and second dorsal origin are located quite close to one another: in the formulation length to the former point has been arbitrarily adopted.

Similar results involving some or all of the morphological landmarks here noted (together with length to second dorsal origin, length to base of lower caudal lobe) plotted at relevant intervals have been encountered in a number of other species, the first point, length to back of mouth, being variously located in different families on log 1, log 2 or log 3. With the slope of the graph decided by the plotting of log length to back of mouth on the appropriate abscissa (ascertained, formally, by trial and error, in practice generally obvious from inspection of relative length of preoral head), followed by the plotting of log total length on either log 9 or log 10 (by trial and error), the precision with which the selected ordinate dimensions when plotted at integral abscissal values approximate the predetermined straight line is indeed striking.

Perforations in body wall. The specimen has two perforations extending from the external surface through the body wall to the coelome, one immediately behind the base of each pectoral. Both are very neatly outlined externally, that on left side ovoid, 7 by 5.5 mm, that on right side somewhat pyriform, 9 by 6, divided near middle of its length by a narrow oblique superficial bar of integument. It is not evident whether these represent pre or post mortem injury.

Family SYNGNATHIDAE

Only seven species are credited to Tasmania in the Check-list (McCulloch 1929), four additional species having been included earlier in the local list of Lord (1927). In a paper by the writer (1968) containing a first record for this State of *Syngnathus poecilolaemus* Peters, 1869, twenty Tasmanian species were enumerated — however, entry XVII, *Hippocampus novaehollandiae* Steindachner, 1866, is to be regarded as a junior synonym of XIX, *H. whitei* Bleeker, 1885. A twentieth species, *Ichthyocampus cristatus* McCulloch & Waite, 1918, was noted in Part XVII (1970, p.35).

Two additional species, *Syngnathus caretta* Klünzinger 1879, and *Ichthyocampus runa* (Whitley, 1931), are here noted, and some general observations are made on *Syngnathus phillipi* Lucas, 1891 and *Syngnathus poecilolaemus* Peters, 1869.

Genus *SYNGNATHUS* Linné, 1758

Syngnathus Linné, 1758, SYST. NAT., ed. 10, p.336. *Ex* Artedi, ICHTH., 1738, gen. 1, p.1. Type-species *S. acus* Linné.

Syngnathus caretta Klünzinger, 1879

Syngnathus caretta Klünzinger, 1879, *Sitzb. Akad. Wiss. Wien*, 80 (1), p.419 (p.95 of reprint). Type locality: Port Phillip Victoria.
Syngnathus caretta: Macleay, 1884, *Proc. Linn. Soc. N.S.W.*, 9, p.60. *Id.* Lucas, 1890, *Proc. R. Soc. Vict.* (n.s.), p.38.
Leptonotus caretta: McCulloch, 1929, *Aust. Mus. Mem.*, 5 (1), p.85. *Id.* Whitley, 1941, *Aust. Zool.*, 10 (1), p.16, fig. 12. *Id.* Munro, 1958, HANDBK AUST. FISH., 21, p.85, fig. 587.
Pugnaso caretta : Whitley and Allan, 1958, THE SEAHORSE AND ITS RELATIVES, p.8. *Id.* Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89 (1), p.37.

History of species. This is one of our lesser known pipefishes, most of the available information about it being derived from Klünzinger's original account, of which Macleay gave an English version in the supplement to the Catalogue (1884), and from some notes by Whitley (1941, p.16) on, and a sketch (fig. 12) of, the holotype, a female, examined by him in the Wurttembergische Naturaliensammlung, Stuttgart in 1937: some additional data is included in the diagnosis in the Handbook (Munro, 1958), which reproduces Whitley's sketch. It may be noted that in his census of fishes recorded from Victorian waters Lucas (1890, p.38) listed this species in parentheses, his

convention for records based on a single specimen or regarded as doubtful in respect of locality, in which latter category he placed all Klünzinger's material reported (1872) as coming from Hobson's Bay or Port Phillip.

Generic status. Klünzinger referred his fish to *Syngnathus* Linné, 1758, in which course he was followed by Macleay and Lucas. However, since the appearance of the Check-list (McCulloch 1929) it has generally been placed by Australian authors in *Leptonotus* Kaup, 1853; with Whitley and Allan (1958) and Whitley in his name-list (1964) including it in *Pugnaso* Whitley, 1948.

Leptonotus differs from *Syngnathus* primarily in exhibiting marked sexual dimorphism, the female having the dorsal profile of the trunk conspicuously elevated, and the median ventral trunk ridge acute, features well marked in the two other species admitted in the Check-list, *L. semifasciatus* Günther, 1870, and *L. costatus* Waite and Hale, 1918, the latter, which differs from the type-species *S. blainvillianus* Eydoux and Gervais, 1837 (formally included in the Check-list, 'Australia (Kaup)'; but the entry has not been confirmed, and the species has been dropped from the more recent name-list of Whitley) in possessing a ridge on the opercle anteriorly, is accommodated by Whitley (1951) in his subgenus *Kaupus*. Whitley noted in the female holotype he examined at Stuttgart 'a median carina along belly', but made no mention of, nor does his figure show, any elevation of the dorsal trunk profile. In our material a ventral trunk ridge is invariably present and usually prominent: the dorsal profile is significantly rectilinear, though it is probable at least some examples are females. It is concluded there is no good reason for transferring this species, described in *Syngnathus*, to *Leptonotus*.

The type-species of *Pugnaso*, *Syngnathus curtirostris* Castelnau, 1872, is devoid of any opercular ridge, a feature constituting part of the generic diagnosis. The subsequent attribution (Whitley and Allan 1958; Whitley 1964) to this originally monotypic genus of the present species with its well marked, though short, keel is hence inappropriate. [The opercular ridge – its absence, its degree of development when present – has long been a vexed item, leading at times to marked differences in taxonomic practice. Thus McCulloch (1921), following contemporary Australian practice, employed the occurrence of a full, and of a partial anterior, ridge in a key separating *Corythoichthys* Kaup, 1853 and *Syngnathus;* and in the Check-list referred to the former genus a group of species that the Handbook, following current Australian practice, assigns to the latter. Again, *Stigmatopora nigra* Kaup, 1853 and *Stigmatopora argus* (Richardson, 1840) have been separated (Waite and Hale 1921; Scott *et al.* 1974) by the criterion that the keel, regularly present in the former, is lacking in adults of the latter; but see Part IV (1960) where an example of *S. argus* 280.5 mm long is noted as having a well defined keel extending across the whole operculum]. While the other differentiae given for distinction between *Pugnaso* and the type-species of *Syngnathus*, *S. acus* Linné, 1758, are valid for that species, they do not provide any acceptable basis for distinguishing *S. curtirostris* generically from a number of other species that the Handbook refers to *Syngnathus*. The present species is thus not compatible with *Pugnaso* as originally defined, and it is felt there are no good grounds for its transfer from *Syngnathus* to that genus.

It should, however, be noted that in meristic characters, length and form of snqut, location and extend of dorsal fin, and in some individuals color pattern *S. caretta* comes closer to *S. curtirostris* than to any other Australian species; being separable from it chiefly by its opercular keel, its ventral trunk carina and, where these are developed, by the supernumerary trunk and/or tail ridges.

Tasmanian material. The present observations are based on 8 specimens: *(a), (b), Ls* 63.7, 64.6, Kelso, Tamar estuary, north coast, 5-6 February 1961, low tide among *Zostera* sp., Q.V.M. Reg. No. 1972/5/206; *(h) Ls* 100.9, Greens Beach, north coast, 5 September 1965, Q.V.M. Reg. No. 1972/5/527; *(d), (e), (f), Ls* 74.9, 75.0, 80.2, Greens

Beach, 17 October, 1965, Q.V.M. Reg. No. 1972/5/555; *(e) Ls* 66.0, 24 March 1976, 1.6 km north of Greens Beach, Q.V.M. Reg. No. 1976/5/132; *(g) Ls* 83.5, 1 km north of Greens Beach, 7 April 1976, Q.V.M. Reg. No. 1976/5/107: all collected by Mr R.H. Green.

Other examples examined: *(i), (j), (k) Ls* 60.6, 64.4, 67.1, same history as *(a), (b)*, Q.V.M. Reg. No. 1972/5/206; *(l)-(s) Ls* 20.1-32.0, $\bar{x}$ 26.1 ± 1.56, same history as *(a), (b)*, Q.V.M. Reg. No. 1972/5/716.

Associated species. Pipefishes taken in association with our material of *Syngnathus caretta* comprise *S. phillipi* Lucas, 1891, *S. curtirostris* Castelnau, 1872, *Lissocampus caudalis* Waite and Hale, 1921, *Urocampus carinirostris* Castelnau, 1872.

Dimensions. Table 1 sets out the principal proportions of specimens *(a)-(h);* arranged in order of increasing total length; the first two lines recording standard length and total length in mm, all other entries being permillages of total length. *S. caretta* is a small species, its length regularly being specified as 10 cm; our largest example has total length 10.3 cm.

TABLE 1

Syngnathus caretta Klünzinger, 1879. Dimensions of 8 specimens from northern Tasmania: standard length and total length in mm, all other dimensions as permillages of total length.

Dimension	*(a)*	*(b)*	*(c)*	*(d)*	*(e)*	*(f)*	*(g)*	*(h)*
Standard length	63.7	64.6	66.0	74.9	75.0	80.2	83.5	100.9
Total length	65.0	66.0	67.2	76.7	77.0	81.9	84.5	102.9
Length to dorsal origin	358	333	350	356	351	349	341	360
Length of dorsal base	65	61	57	72	69	71	50	68
Length to vent	369	364	372	365	361	354	360	389
Length of pectoral	18	-	-	20	22	17	12	15
Head	111	105	104	102	104	100	96	97
Snout	38	41	36	40	39	34	36	31
Eye	20	19	21	20	22	20	15	19
Interorbital at middle of orbit	18	20	19	14	25	15	15	16
Interorbital at front of supraorbital ridges	11	9	10	10	14	8	11	12
Depth of snout, minimum	15	14	13	14	16	13	11	14
Depth at hind border of orbit	31	27	29	30	29	27	24	29
Depth at opercular border	36	31	31	35	22	35	31	36
Depth at vent	29	24	24	29	30	26	24	30
Depth of trunk, maximum	39	29	31	33	38	31	33	37
Width of snout, minimum	8	8	9	11	9	11	11	11
Width at hind border of orbit	31	30	30	27	26	27	24	27
Width at opercular border	26	25	27	25	23	22	22	24
Width at vent	29	17	18	35	26	24	21	29
Width of trunk, maximum	31	28	28	34	27	32	24	29

Meristic characters. Annuli 18 + 43 (2 specimens), 44, 45 (2), 46 (2), 47. Subdorsal 0.5, 0.9 (2), 1.0 (2), 1.1, 1.5, 1.8 + 4.1, 4.3 (4), 4.4, 4.5 (2). P.8/8, 9/9 (2), 10/10 (3); damaged in 2 fish. A. 3 (5), 4 (1); not detected in 2 fish. C.9.

Proportions. The following suite of proportions includes most of those commonly reported by workers on syngnathids. Head in trunk 2.10-2.75, $\bar{x}$ 2.48 ± 0.0649; in *Lt*

9.03-10.43, $\bar{x}$ 9.81 ± 0.155. Head and trunk in tail 1.57-1.78, $\bar{x}$ 1.73 ± 0.0254; in *Lt* 2.69-2.82, $\bar{x}$ 2.76 + 0.0138. Length to dorsal origin in *Lt* 2.75-3.00, $\bar{x}$ 2.85 ± 0.0273. Dorsal base in length to origin of fin 4.93-6.86, $\bar{x}$ 5.55 ± 0.0699; in head 1.41-1.93, $\bar{x}$ 1.62 ± 0.0675. Eye in head 5.00-6.48, $\bar{x}$ 5.43 ± 0.168; in snout 1.64-2.40, $\bar{x}$ 1.93 ± 0.829. Snout in head 2.52-3.13, $\bar{x}$ 2.76 ± 0.977. Interorbital, measured at middle of orbit 0.85-1.33, $\bar{x}$ 1.07 ± 0.0409 in eye, measured between supraorbital ridges at front of orbit 1.39-2.29, $\bar{x}$ 1.89 ± 0.112. Maximum depth of trunk in *Lt* 28.8-39.2, $\bar{x}$ 33.88 ± 1.27; in head 2.63-3.58, $\bar{x}$ 3.12 ± 0.107. Maximum width of trunk in *Lt* 23.7-33.9, $\bar{x}$ 29.03 ± 1.45; in head 3.00-4.05, $\bar{x}$ 3.55 ± 0.199.

Head, trunk, tail. As might be expected, relative (*e.g.*, *Tlt*) values of such primary elements of length of fish as head, trunk, tail are tolerably constant, ranges being 96-111, 257-268, 628-642, with coefficients of variation 4.3 ± 1.1, 1.3 ± 0.3, 0.7 ± 0.2 (contrast, for instance, eye, with V = 11.7 ± 3.0). The noticeable larger V for head is attributable, not to greater random variation than that exhibited by other regions, but, as is suggested by inspection of table 1, to the existence of significant (negative) correlation of length of head with length of fish: r = − 0.807 (z = 1.197); t = 3.346*.

Mean values of lengths of head, trunk, tail for the present sample yielded a significantly straight line when plotted against logs 1, 2, 10, respectively. With lengths as *Tlt*, L = 534.68 log N + 102.50, giving predicted values as follows (measured values in parentheses) 102.5 (102.3), 263.5 (261.4), 637.2 (636.5) ; t = 346.36***. For absolute dimensions, mm, the equation is L = 41.92 log N + 7.79; predicted (measured) values 7.79 (7.89) 20.40 (20.26), 49.71 (49.75) ; t = 170.29. It would appear that the differential growth of head relative to overall size is more or less balanced out in the mean head length, the *Ls* distribution of the sample being tolerably symmetrical, with skewness, calculated by the mean-median formula, + 0.0991, and with 6 items lying within $\bar{x} \pm s$.

It is of interest to note that in the sample of 9 males and 15 females of *S. curtirostris* discussed below the mean lengths of head, trunk, tail are also linear on logs 1, 2, 10, though not with the extremely close fit found for *S. caretta*. With mean lengths of the three regions as *Tls* (*Tlt* in *S. caretta*) the regression equation is L = 493.66 log N + 118.86 yielding calculated (measured) values 267.5 (259.3), 276.5 (259.3), 612.6 (615.0) ; t = 34.95***. No significant correlation subsists between any of the three regions and *Ls*. Skewness, though not excessive, is markedly greater than in the smaller *S. caretta* sample, being +0.371: 19 entries lie within one standard deviation on either side of the mean (*cf.* 16, normal curve).

Cristae of trunk and tail. The system of body ridges in *S. caretta* is a quite unusual one, including some ridges not or rarely found in other species and presenting a remarkable diversity both of pattern and ridge structure. The facultative (in our material constant) presence of a median lateral caudal ridge is reported both in the original description and in Whitley's notes on the type, but is not mentioned in the Handbook diagnosis. There appears to be no published reference to the dorsal and ventral caudal ridges, or to any supernumerary lateral trunk ridges present in some individuals (where present inconstant in number and relative location; contrast the two regularly occurring and normally disposed lateral trunk ridges of *Urocampus carinirostris* Castelnau, 1872).

Ridges are here denoted by a two-letter symbol thus: first letter either T = trunk or C = caudal; second letter one of these, S = superior (*i.e.*, superolateral), I = inferior (inferolateral), D = dorsal (here and normally median), V = ventral (here and normally median), L = lateral (if single normally median). This system in general follows that employed in the Handbook (Munro 1958), except that, to render L available for lateral, U and L for upper and lower are here replaced by S and I. Both systems are simpler than that using 3 or 4 letters devised by Herald (1953, p.233,

fig. 36). The convenience afforded by that scheme of having a systematic symbol, LTAR, for the taxonomically important 'lateral tail ridge', the short forward extension below dorsal base of CS, is gained at the formal cost of having two symbols associated with a single crista: in any case, the presence or absence of this segment is implicit in the specification of TS and CS as discontinuous or continuous. Annuli are here denoted by T or S followed directly by an ordinal numeral.

TS from just behind head along superolateral edge of trunk to near dorsal origin, swinging down below fin base, ending on $C2^{nd}$, 3rd (one case 4th). CS forward from caudal fin to shortly behind dorsal base, swinging down below it to end, below TS, on $T18^{th}$ or $C1^{st}$; in two specimens (in one on one side only) continuous or subcontinuous with a supernumerary TL. T1 and C1 continuous; left and right T1 continuing forward to fringe opercular borders, usually meeting mesially. TD from head (just behind, sometimes subcontinuous with, occipital ridge) to dorsal, one specimen from $T6^{th}$ for 3 rings only, one specimen developed only on $T1^{st}$. CD usually traceable from just behind dorsal to about $C20^{th}$-35th, one case to caudal fin; variable in structure. TV from head, one specimen $T4^{th}$, to vent; moderate to strong. CV from $C1^{st}$, 2nd usually to about $C25^{th}$, sometimes to caudal fin; variable in structure. TL most aberrant, most variable (sometimes marked difference on two sides), one, two, or three ridges; main types of pattern as follows (*i*) single ridge, median, either ending in a short downward turn free on T18, C1 or continuous or subcontinuous with CL or with C1; (*ii*) two ridges, primary, median surmounted by short accessory ridge on $T15^{th}$-17th; (*iii*) three ridges, more or less full length, uppermost continuous with CS, two members meeting in an arc on $C2^{nd}$, both here continuous with C1, or, again, three (lowest on 9 rings only) meeting at one point, here continuous with CL, uppermost virtually continuous with CS. CL continuous or subcontinuous with TL or originating on $C1^{st}$-4th, traceable, continuous or interrupted, for at least 10, usually upward of 20, rings, sometimes to end of tail.

While TS, T1, CS, C1 and, somewhat less consistently, TD, TV are in general normal in structure, being either even ridges or sometimes wholly or partly noded with small bosses at ring junctions, the remaining ridges are surprisingly diverse, presenting strong well separated knobs, short dashes either horizontal and collinear or oblique and parallel, either briefly separated or briefly overlapping, with or withour terminal contact, links more or less completely combining to form a chain, spaced mammillary eminences, sometimes included within a groove; the ridge as a whole being either continuous or interrupted, consisting of one or more of the above-noted elements.

Ridges of head. Rostral ridge barely developed in first one-third of snout, thereafter rising, straight or gently concave, to above nostril, thus forming a subtriangular plate, with base subequal to height of upper jaw there; behind level of nostril lapsing as a very low, sometimes indeterminate, ridge terminating above pupil. Strong supraorbital ridges arising between nostril and margin of rostral ridge, diverging backward to about thrice their initial interspace. Dorsum of head usually with a rather sharp median ridge, extending, continuously or commonly in 2-3 segments, from near level of hind border of orbit almost to, occasionally to, origin of TD. A low ridge from tip of snout to middle of orbit along border of upper jaw. Low ridges continuing just beyond orbit delimiting lower margins of lower jaws; between these a strong median ridge bifurcating beneath the eye, the tips meeting two pronounced rounded prominences, each surmounted by a short subcylindrical process.

Opercular keel distinct, straight or slightly convex upwardly, short 0.2-0.45, modally about 0.3, horizontal extent of operculum here.

Other features. Metrical characters commonly incorporated in species descriptions have been given above. Trunk and tail subquadrangular. Snout tip somewhat turned up. Eye set high, supraorbital ridge constituting part of dorsal profile, distance of orbit from ventral profile little more than diameter of small pupil. Interorbital and dorsum of head behind it for an eye diameter a single plate, flat or slightly concave

transversely. Most of head, including nearly all snout, with striae or vermiculations. Trunk and tail scutes with patterned striae, chiefly lyrate or resembling a mitotic spindle; some specimens with most or all of the dorsal and lateral scutes with a subcircular, oval or rhombic area against anterior border less conspicuously marked. Pectoral rounded or very slightly pointed, its length rather more than twice its base. Caudal rounded or obtusely pointed. Dorsal base not elevated, fin of moderate height. Anal minute.

Coloration. Available information on coloration does not extend beyond that given in the one-sentence note by Whitley, virtually an englishing of the original description: 'Brownish black; on the back ... light tortoiseshell-like transverse blotches or crossbands at different intervals from one another, about twelve in number'. Save for specimens *(a)*, *(b)*, *(e)* the first of which is light brown, the second medium brown with good development of the multi-toned marbling from which the species gains the handbook vernacular name of 'tortoiseshell pipefish', while the third is conspicuously bicolor (head and trunk medium brown, somewhat lighter ventrally, tail pale dull yellow), the overall appearance in the eight-specimen sample here reported on is very dark brown, or black, elements of the pattern being inconspicuous, discernible at times only on examination with a lens.

The present paragraph relates only to *(b)*. (*i*) *Trunk and tail. Dorsal surface.* Medium brown, with the characteristic tortoiseshell markings in various tones of light and dark fawn, yellow, whitish, silvery, forming blotches or crossbars on T2nd-3rd, 4th-5th, part 6th, 10th-11th, 14th-15th, near dorsal origin (indistinct); on tail at 2nd- 3rd, 6th- 7th, 11th, 17th (flanked on each side by blackish bar), 23rd (complete black bar in front, incomplete behind) 28th (like 23rd), 34th (like 17th). *Lateral surface.* Most of the light areas on dorsal surface extend to at least upper half of lateral surface, that on T2nd-3rd (here receiving increment from T1st) and that on T4th-6th reaching almost to ventral profile, most of those on tail similarly prolonged. Between these light bars brownish, sometimes with reddish stippled and/or vermiculated with lighter. *Ventral surface.* More or less even dark warm brown; on tail briefly invaded by several of the lateral light areas. A small white mark on each TV and each CV; on some anterior trunk rings short dashes, elsewhere small, or minute, well-defined spots. (*ii*) *Head. Dorsal surface.* Snout even medium brown save for small yellow patch just behind upper jaw, white triangle over front of orbit, reddish band above pupil, several transverse sinuous proconcave whitish arcs above back of orbit, thereafter brownish with ridges glistening, obscure dark spot on occiput. *Lateral surface.* Tolerably even warm brown, rostral crest lighter. *Ventral surface.* Warm median brown, darker on opercles, here narrowly rimmed with black.

Chief variations included the following. *Trunk*: Dorsal surface with two lateral deep yellowish markings, continuous circles, cross bars or colons; tortoiseshell patches noted in *(b)* sometimes pearly, exceptionally one or two yellowish; in *(g)* lower lateral trunk scutes each with dark centre flanked on each side by goldish and surrounding two gold spots; in *(e)* each ventral scute brownish with central aureate area, extending full width in last 2-4 rings, narrowing to extinction anteriorly. *Tail.* In *(e)* dorsal surface yellowish or deep straw with somewhat darker median line; lateral surface sometimes dark brown or blackish, immaculate; ventral surface usually lightest, occasionally with some tortoiseshell marking. *Head.* Tip of snout often white, whitish, or light horn; postorbital dorsum dark brown delicately mottled with lighter tortoiseshell; apart from light snout tip virtually uniform dark brown; several white dots on ventral surface and one small white patch at upper angle of operculum.

Dorsal whitish or pale straw, occasionally faintly reddish anteriorly and/or basally; each ray with several strokes of reddish brown, tip usually whitish. Pectoral whitish or pale yellowish, rays somewhat greyish. Caudal variable: even dark brown, dark brown becoming yellowish towards tip, yellowish becoming darker in distal one-fifth or so. Anal hyaline or whitish.

Syngnathus phillipi Lucas, 1891

Syngnathus phillipi Lucas, 1891, *Proc. R. Soc. Vict.* (n.s.), 3, p.8. Type locality: Port Phillip Heads, Victoria.
Syngnathus phillipi: Waite and Hale, 1921, *Rec. S. Aust. Mus.*, 1 (4), p.297, fig. 30. *Id.* Munro, 1958, HANDBK AUST. FISHES, 20, p.83, fig. 575.
Corythoichthys phillipi McCulloch, 1911, *Zool. Res. Endeavour*, 1, (1), p.26, fig. 10; and 1929, *Mem. Aust. Mus.*, 5 (1), p.87.
Parasyngnathus phillipi Whitley and Allan, 1958, THE SEAHORSE AND ITS RELATIVES, p.8. *Id.* Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89 (1), p.36.

Tasmanian occurrence. As pointed out in Part IV (1939, p.143), although the Check-list (McCulloch 1929, p.87) gives Victoria and South Australia only, this species was reported by Waite and Hale (1921, p.298) also from Western Australia, while earlier McCulloch (1911, p.26) had noted 4 *Endeavour* specimens from Oyster Bay, east coast, Tasmania. A male example dredged in 16-24 m off Verona, D'Entrecasteaux Channel in 1961 was the subject of some observations in Part XI (1963, p.17).

The species proves to be quite common in this State, having on various occasions been taken in considerable numbers in those areas (lower reaches of Tamar river and northern coast adjacent to the estuary) in which most of the collecting of the Queen Victoria Museum has been carried out, being here the most abundant pipefish after, or along with, *S. curtirostris* Castelnau, 1872 — the latter being the subject of notice in several contributions in this series, namely, Parts VI (1953, p.250), XII (1964, p.85), XIV (1966, p.93).

Material. (*a*) 25 specimens collected by Mr R.H. Green at low tide among *Zostera* sp., at Kelso, estuary of the Tamar, north coast, on 5-6 February 1967 (Q.V.M. Reg. No. 1975/5/716); (*b*) 2 specimens collected by Mr G. James at Dianas Basin, east coast, on 2 September 1972 (Q.V.M. Reg. No. 1972/5/514).
Sex ratio. (*a*) 9 males, 16 females (one female damaged; not considered below); (*b*) 1 male, 1 female.
Meristic characters. Annuli: trunk annuli invariable at 18 in both samples; caudal (*a*), males 43 (2 cases), 44 (5), 45 (1), 46 (1), females 42 (4), 43 (4), 44 (3), 45 (2) 46 (2); (*b*) male 47, female 44. Subdorsal annuli: (*a*) males, trunk 0.4 (1), 0.5 (2), 0.7 (2), 1.0 (3), 1.1 (1), tail 5.0 (1), 5.4 (1), 5.5 (2), 5.6 (1), 5.8 (1), 6.0 (2), 6.1 (1), females, trunk 0.5 (3), 0.7 (1), 0.8 (1), 0.9 (5), 1.0 (3), 1.3 (1), 1.4 (1), tail 5.1 (1), 5.2 (1), 5.5 (1), 5.6 (2), 5.8 (1), 5.9 (4), 6.0 (5); (*b*) male 0.8, 6.3, female 1.0, 5.4. Dorsal rays: (*a*) males 20 (1), 21 (1), 22 (4), 23 (2), 25 (1), females 20 (2), 22 (4), 23 (3), 24 (1), 25 (4), 26 (1); (*b*) male 26, female 23. Pectoral rays: (*a*) males 9 (1), 10 (5), 11 (2), 12 (1), females 9 (1), 10 (10), 11 (3), 12 (1); (*b*) male 9, female 9. Anal rays: (*a*) males 2 (4), 3 (5), females 2 (4), 3 (11); (*b*) male 2, female 2. Caudal rays: (*a*) males 9 (1), 10 (8), females 9 (2), 10 (13); (*b*) male 10, female 10.
Body regions. Measurements of standard length, total length, head, trunk, tail are set out in table 2, *Ls*, *Lt* being in mm, other dimensions as *TLs*: the ratios head in trunk, in tail, eye in snout, snout in head are also recorded.
Variation within sample (*a*). *(i) Absolute size.* Males show some tendency to exceed females in length, fewer than a quarter of the males but more than half the females having *Lt* 100: however, the difference between the means is not formally significant (nor is that of *Ls*). *(ii) Head, trunk tail as TLs.* The relative length of the head is significantly greater in females (t = 2.862*), as also probably is that of trunk (t = 1.977, slightly below P 0.05; *cf.* also greater value of female in Dianas Basin sample), the relative tail being concomitantly shorter (t = 2.654*). *(iii) Proportions.* No significant differences between the sexes if found in any one of the four ratios reported on in table 2.
Variation within Dianas Basin sample. Excess of the male or female value follows the

same pattern as in the larger sample, except in the ratio head in trunk, the larger value here being that of the female.

Variation between samples. The absolute size of the Dianas Basin male lies outside the range of the large sample, but that of the female falls within it: however, the difference between the means of the samples is significant (*Ls*, t = 2.464*; *Lt*, t = 2.568*). Attention was first called to the east coast male by the large value for trunk in tail, which, at 3.01, much exceeds the 2.4 of the Handbook (Munro 1958, p.83) and of the conspectus in Part X (1961,p.59). Comparison with data for the Tamar River sample shows the exceptionally high numerical value of the ratio is contributed to both by a relatively shorter trunk and a relatively higher tail. The tail of the female also is relatively long, its *TLs* value exceeding those of all but one of the 15 females of the other sample. The means of the two samples (sexes pooled) show significant differences, additional to those for *Ls* and *Lt*, in respect of trunk (t = 2.633*). tail (t = 3.288*), trunk in tail (t = 2.146*).

Attention is here drawn to these differences as suggesting the possible occurrence of somatic variation with topographical distribution.

Brood pouch. The extension of the (essentially subcaudal) brood pouch is reported by Lucas as being 'over the first 15-18 tail rings', by Waite and Hale as 0 (1) + 16 (15-18), the latter figures being adopted in the conspectus. In the example noted in Part XI the (empty) pouch folds narrowed to extinction on the sixteenth tail ring.

In the present Tamar series the (gravid) pouch subtends 1 + 15 rings (1 specimen), 1 + 16 (1), 0 + 17 (1), 1 + 17 (1), 0.5 + 18 (3), 1 + 18 (2); in the Dianas Basin male 0 + 17. The pouch proper, *i.e.*, the egg-bearing bursa, is wholly subcaudal, but forward continuations of the roots of the folds may extend on to the last trunk annulus, the extension here being somewhat conventionally assessed as the whole or half the annulus.

Expressed as permillages of standard length, the pouch represents 232-296, $\bar{x}$ 265.2 ± 7.03 (s 21.1 ± 4.97, V 7.9 ± 1.9); or, as permillages of length of tail without caudal fin, 365-503, $\bar{x}$ 426.2 ± 13.48 (s 40.45 ± 9.53, V 9.5 ± 2.3). No correlation of either variate with length of fish obtains. In the Dianas Basin male corresponding values are 272, 399.

No reference to the nature of the pouch is to be found in either of the two main treatments of the species (Lucas; Waite and Hale), or in the note on the 4 *Endeavour* examples from Tasmanian waters (McCulloch 1911, p.26, fig. 10) the first notice apparently being that in Part XI (1963). In the specimen there described and illustrated (fig. 5) the pouch, which was empty, and which either had not reached or (perhaps more probably) had regressed from its full development, consisted of two simple folds, devoid of supporting plates, narrowly separated anteriorly by the interposition of the minute anal fin, becoming progressively widely divergent posteriorly to end on the sixteenth caudal annulus almost the full width of the tail apart, the hinder portion being adnate to the general caudal surface.

All nine males of (*a*) bear a well developed pouch. In two individuals the ova show no significant signs of development (both have one full sized opaque pale yellow infertile ovum); in three an early embryo is apparent in most ova as a slender whitish or pale yellowish band extending from less than half around the sphere to more than a complete encirclement of it; in three the eyed stage has been reached, the embryo in the most advanced set constituting about half the total bulk, and several embryos showing the onset of pigmentation: in the remaining example the pouch is empty, apparently in a fairly early phase of regression.

As already reported (1963, p.17) the integumentary folds are devoid of supporting

plates. In the void specimen, they are in contact mesially throughout most of their length, but in the gravid individuals they are disparted in varying degrees by their contents, the position of the ova being clearly indicated externally by two series each of about a dozen rounded bulges. Each bulge exhibits about a dozen fine transverse ridges (these persist in the individual with the collapsed pouch). The overall color of the folds is usually much like that of the tail in general, but may be either somewhat lighter or somewhat darker. Irregular wavy lighter lines, confined to part of an annulus or extending over several annuli, cover most of the fold, up to a dozen often occurring side by side.

In one of the two fish with undeveloped ova the whole egg mass worked free during the course of examination. Bright orange, broadly fusiform, somewhat flattened dorsoventrally, length 22.5 (length of pouch, without terminal roots 26.3, with roots 29.8), greatest width 5.5, greatest depth 4. The 36 ova in two layers; outer in two tolerably regular rows, on right side (of fish) 12, on left 10, first on left beginning behind first on right, last on left ending partly in advance of last on right; at front and back an azygous ovum, front one more closely approaching right series, hind one more nearly part of left; an inner layer of 12 below middle of outer layer, first two, last two uniserial, rest in four side-by-side pairs. Most subspherical, modal diameter about 2 mm, some considerably compressed anteroposteriorly. Largely enveloped in a whitish ovarian membrane, which forms a pronounced fold between the two linear series of outer layer.

Floor (dorsal surface) of pouch pale orange, lightly and patchily peppered with reddish brown. Divided into 23 compartments, in two rather irregular rows, variable in size, area of largest nearly double that of smallest, and in shape, mostly more or less quadrilateral or rounded. On left fold 11 irregular and often imperfectly constituted compartments, on right some extensions from floor of septal walls forming incomplete cells: both folds lined with glistening pale grey membrane. Septa on floor erect, tolerably stout but flexible, height at middle of pouch about 1.3; hyaline, with minute greyish or dark brownish punctulation.

Pouch folds in single male of (*b*) narrower than in (*a*); free margins widely separated, near middle by more than one-third total width of tail here. No distinct signs of septa on floor or on walls; both with what appear to be remnants of a whitish covering or partial covering, possibly of a cereous nature, more nearly continuous on folds, mostly scattered on floor, which exhibits typical lyrate pattern of striae of general external caudal surface, not here traceable in any specimens of (*a*).

Conspectus values. In the conspectus of Tasmanian syngnathids in Part X (1961), which gives (in addition to maximum length and two qualitative features) known meristic and morphometric values for eight characters, the entries for this species were based primarily on Waite & Hale's review of the South Australian lophobranchiates (1921, p.297), which cites also (in parentheses) some counts from the original description, and from which the diagnoses of the Handbook is directly derived. With the addition of some calculations based on measurements of four type-specimens and of a Tasmanian example noted in Part XI (1963, p.17), three single-value entries in the conspectus were extended to become ranges. With incorporation of the present data, counts and ratios now stand as follows (new ranges in parentheses). Annuli 18-20 + 40-48; subdorsal annuli 0-1 + 5-6 (0-1.4 + 5.0-6.1); brood pouch annuli 0-1 + 15-18. Dorsal 22-28 (20-28). Eye in snout 3.1-3.4 (2.63-3.68); snout in head 1.7-2.0 (1.7-2.58); head in trunk 1.8-2.4 (1.69-2.42); trunk in tail 2.32-2.9 (2.1 -2.9).

For three fin counts not recorded in the conspectus our ranges (values of Waite & Hale in parentheses) are A. 2-3 (2-3), P. 9-12 (10-12), C. 9-10 (10).

Supposed sexual dimophism. With the type material before him (no holotype or paratypes specified: some dimensions for 2 males 2 females tabulated), Lucas stated 'In the males

there is a marked tetrahedral prominence on the ventral surface of the head, just behind the level of the eyes, formed at the point of union of the median ventral ridge of the snout, a transverse ridge along the origin of the operculum on either side, and the median ventral ridge of the head, continuous with that of the trunk behind. This projection is quite wanting in the females'.

This feature received no notice from Waite and Hale (1921); nor was it observed in the Tasmanian male reported on in Part XI, the suggestion there being advanced that it is 'perhaps merely the inter-ramal triangle of the normal jaw structure adventitiously swung down (as so often happens), but, by coincidence in this case, only in male examples'. Examination of the present material supports this view. In (*a*) a marked prominence is found, about equally developed, in one male and one female, while a minute subcircular median prominence occurs at the relevant location in two males and three females: in (*b*) the male is here smooth, the female presents a triad of low rounded elevations.

Coloration. Comparison of our material with accounts of coloration provided by Lucas and by Waite and Hale shows agreement for all specimens in the following respects — sides and back brown, males darker than females, ventral trunk ridge black. However, consideration clause by clause of the earlier descriptions discloses a number of cases of partial agreement or of disagreement as follows.

'Narrow, whitish, vertical bands near front border of several of the lateral plates' (Lucas): whitish bars in 3 males 5 females, lighter but not whitish in 1 male 2 females, barely recognizable or represented by a few spots in 7 females, not present in 5 males. 'In some of the males, white spots instead of bands' (L): 2 with bands and spots. 'Under surface lighter' (L): barely so (especially in trunk) in 5 males. 'In some of the females, rows of black spots across operculum, and on under surface of snout' (L.); females with 'underside with a row of dark brown dots on each side, extending from anterior portion of snout to the termination of the opercular ridge' (W. & H.): some spots, medium brown to dark brown not black, on some or all of three regions, snout, chin, operculum, on whole snout of 7, on about half in 5, on one-third in 1, not on snout 2. 'Upper surface of head, operculum, and snout with irregularly white lines, bands, or patches, more or less conforming to the ridges' (L.); males with 'head and snout brown above with white mottlings' (W. & H.): a few irregular white lines, or spots (chiefly on, or near, operculum; usually annulated with brown), or small patches in 5 males 7 females, no white markings, ridges on dorsum of head brown (light-dark), in 4 males 8 females.

Males (W. & H.). 'Opercular ridge with five dots along its length, decreasing in size backwards': 5 dots in 5 (in 1 last 2 confluent), 4 in 1, 2 rows of 5-6 in 2, 8 very small in 1; general, but not invariable, decrease in size backwards. 'Chin opalescent with white markings': opalescent in 8, with white markings in 3 (1 with 1 white mark, 2 with 2). 'Back with about sixteen pairs of irregular, whitish spots between the nape and the end of the tail': about 12 pairs in 1, vague indications of possible spots in 2, no spots in 5; 1 has several dark spots on dorsum of trunk. 'Upper half of each lateral body scute with a brown bar': more or less distinct bars in 7, general local darkening in 2. 'Anterior part of lower lateral ridge with a row of seven white spots decreasing in size backwards': 0 in 2, 4 in 1, 5 in 1, 7 in 3 (very faint in 1), 8 in 1, 9 in 1. Lucas makes no mention of the brood pouch, described by Waite & Hale as 'whitish streaked with brown'. Notes on the 9 Kelso males yield: olivaceous, light olivaceous, light olivaceous with some darker areas and with some dark grey, brownish olivaceous, brownish olivaceous with some greenish, olivaceous partly somewhat dusky, partly somewhat greenish brown partly dark slate, pale brownish and deep fawn. Regularly marked with undulating lines that are variably whitish, greyish, dusky, or brownish, sometimes showing some difference on different folds. 'Subcaudal scutes light brown with a dark brown spot on each side of the anterior edges': 2 with some mesial darkening, obscurely delimited, no spots, 3 almost

uniform with lateral dark spots (or short lines); 2 with mesial darkening and spots, 1 with main area flanked by spots with 2-3 series of short midbrown longitudinal wavy lines; in general, lateral ridge between dark spots or lines lighter than ground colour, approaching white; markings usually more prominent in anterior part of tail. (In females, which are very variable, anteriorly each scute may present a mainly longitudinal mesial region, or one or two (side by side) darker rounded (in 1 later subtriangular) regions; posteriorly, these may break up into smaller units or may fade out; additional markings, usually longitudinal, may develop posteriorly (in 1 faint dark cross bars); as in males dark spots or lines, usually with whitish interspaces, lie along lateral borders). 'Caudal dusky': chiefly light brown in 1, medium brown in 2, dark brown in 2, dusky in 2, some rays brown remainder whitish in 2; in 3 distal and one or both lateral borders from quite narrowly to quite widely (especially terminally) whitish or (1) yellowish. (In females light brown in 4, medium brown in 3, dark brown in 2, faintly dusky in 3, dusky in 1, whitish proximally then deep amber, with 2 rays whitish, in 1; 3 tipped whitish, 7 yellowish).

Dorsal and lateral surfaces of tail, not described by Lucas or by Waite & Hale. Dorsal: uniform brownish, immaculate in 5 males, 8 females, some indefinite mesial darkening in 1 male, 4 females; a short series of small brown spots at middle of borders of anterior scutes in 1 male, in part faintly olivaceous in 1 male, indications of oblique crossing lines anteriorly in 1 male, narrow dark medial line in 1 female, several anterior annuli with a white spot in 1 female, short whitish strokes anteriorly in 1 female: in both sexes dark spots along junction of dorsal and lateral surfaces may encroach somewhat on former. Lateral: uniformly light brownish in 1 male 1 female; in 7 males 8 females some diffuse central darkening in each scute in anterior half or two-thirds of tail, markings usually breaking up or fading out posteriorly (becoming longitudinally ovate in 1 male, forming almost full bars in 1 male, being followed in 1 male by a dusky goldish spot at middle of each annulus junction, in 1 female darker subcircular areas joined by longitudinal stripe); in 1 female median darkening in linear form; in 2 females 2-3 light wavy lines in each annulus; in 1 male a hemispherical dark marking rising from almost full width of ventral border mostly to half, in parts to two-thirds, height of scute; in 3 females annuli marked off, for from two-thirds to whole height, by subvertical or proconcave silvery bars, each tending to break up posteriorly into 1-3 spots; in both sexes normally with alternate light and dark sections along ridges.

The two Dianas Basin specimens exhibit two noteworthy features, the presence in the female on most annuli of the ventral surface of a short light median line, 5 conspicuously whitish, and on the dorsal surface of each annulus in the anterior half of the trunk a dark brown spot or streak on the lateral ridge, later forming a more or less continuous line, much better developed on right than on left side.

A constant feature of the colour pattern, present in all specimens of both our series, that has not hitherto been the subject of the published comment is the presence at the beginning of the dorsal base — surrounding, and commonly involving the base itself and briefly extending on to the first ray —of a small pigmented area, its diameter rather less than one-third of width of fish here, regularly darker than back in general, ranging from fairly dark to very dark brown, occasionally black.

The most noteworthy points arising from the above analysis include absence in most specimens of series of paired white spots on back between nape and tail reported by Waite and Hale (not noted by Lucas); relatively few white markings on head (contrast both accounts) and the general replacement of these on cephalic ridges by brown lines (contrast Lucas); difference in colour of caudal; together with a more or less marked measure of inconstancy of some other characters previously reported. It is not possible, on available data, to determine to what extent these differences may be attributed to possible variation with locality, mode of preservation or other factors.

Depth. Herald (1953) has drawn attention to the fact that the pipefishes taken in the Marshall and Marianas Islands in Operation Crossroads in 1946 seem to be clearly divisible into intertidal and deepwater forms, with the demarcation of the two habitats at 10-15 feet (3-5m). Some notice of the very meagre information on the depth at which our syngnathids occur appears in Parts X (1961, p.61) and XI (1963, p.19).

The position regarding the present species is problematical. On the one hand it has been dredged — in 9-13 fm (16-24 m) (Scott 1963), no depth stated (Lucas 1891, Waite and Hale (18), McCulloch 1911: on the same page as McCulloch's account of the *Endeavour*'s Oyster Bay specimens of this species one of the five localities cited for *Centriscops humerosus* Richardson, 1846 is 'Oyster Bay, Tasmania, 40-60 fathoms', [73-110 m]). On the other hand, it has been collected in shallow water — the Kelso fish were obtained at low tide. Scott *et al.* (1974) state that in South Australia the species is 'quite common in shallow weedy areas in our Gulfs', and while the depth at which the Dianas Basin specimens were taken is not recorded it was probably inconsiderable.

Breeding season. A summary of the available information on the breeding season or seasons among Tasmanian pipefishes has been given in Part XVIII (1970, p.123), where the entry for *Syngnathus phillipi* reads 'pouch present, perhaps not fully developed [more likely in regression?] 23 July (Part XI 1963, p.17, fig. 5), ovigerous November, January, February, (unpublished).' As noted above, of the 9 Kelso males, taken on 5-6 February, 1 has an empty pouch (probably recently discharged), 2 bear undeveloped ova, 3 early embryos, 3 eyed embryos; while the Dianas Basin male, taken on 2 September, has an empty pouch. The period over which a pouch is present in this species in Tasmania thus extends over at least 11 months, the known ovigerous season being the four months November-February.

Maximum length. The total length attained by *S. phillipi* represents about the median value for Australian species of *Syngnathus*, values accepted by the Handbook (Munro 1958), which range from 80 to 270 mm, being greater in 8, less in 7, species. Reported maximum lengths include 107 mm (Lucas), 130 mm (Waite and Hale), 140 mm (Munro), 140 mm, (Whitley and Allen 1958), 140 mm (Scott *et al.*), 126.5 mm (present material).

Genus *ICHTHYOCAMPUS* Kaup, 1853

Ichthyocampus Kaup, 1853, *Arch. Naturges.*, 19, p.231. Type-species, *Syngnathus carce* Hamilton-Buchanan.

Ichthyocampus runa (Whitley, 1931)

Festucalyx (Campichthys) runa Whitley, 1931, *Aust. Zool.*, 6 (4), p. 313). New name for *Ichthyocampus filum*: McCulloch, 1909, *Rec. Aust. Mus.*, 7 (4), p.318, pl. 90, fig. 1, Sydney specimen; not *I. filum* Günther, 1870 (type locality, Bay of Islands, New Zealand, designated by Whitley, 1931).
Larvicampus runa Whitley, 1948, *Rec. Aust. Mus.*, 22 (1), p. 75.
Lissocampus affinis Scott, Glover and Southcott, 1974, MAR. AND FRESHW. FISH. S. AUST., p. 126, fig. on p. 126. Not *Lissocampus affinis* Whitley, 1944.

Remarks. A pipefish collected at Greens Beach, northern Tasmania, by Mr R.H. Green on 18 February, 1976 (Q.V.M. Reg. No. 1976/5/134) was determined by the writer as conspecific with the fish listed and figured by Scott *et al.* (1974) as *Lissocampus affinis* Whitley, 1944; that identification, however, being doubted. In answer to my inquiry, Mr C.J.M. Glover, Curator of Fishes, South Australian Museum, has been good enough to supply, *in litt.*, the information that since the publication of the South Australian catalogue it has been realized a misidentification had occurred, and the specimen figured had already been forwarded to Mr C.E. Dawson, Senior Ichthyologist, Gulf Coast Research Laboratory, Ocean Springs, Mississippi, U.S.A. The Queen Victoria Museum

TABLE 2

Syngnathus phillipi Lucas, 1891. Dimensions (standard length, total length, mm; other dimensions, permillages of standard length) and proportions of a sample of 9 males 15 females from Kelso and Low Head, Tamar River, north coast, and a sample of 1 male 1 female from Dianas Basin, east coast, Tasmania.

Feature	Tamar River					Dianas Basin
	Sex	Range	$\bar{x}$	s	V	
Standard length	Male	96.0-110.0	102.1 ± 1.72	5.16 ± 1.22	5.1 ± 1.2	124.0
	Female	88.5-112.0	98.5 ± 1.49	5.79 ± 1.06	5.9 ± 1.1	101.4
	Pooled	88.5-112.0	99.8 ± 1.29	6.30 ± 0.909	6.5 ± 0.9	
Total Length	Male	97.9-112.0	104.5 ± 1.74	5.22 ± 1.23	5.0 ± 1.2	126.5
	Female	90.7-114.4	100.8 ± 1.49	5.78 ± 1.06	5.7 ± 1.1	103.4
	Pooled	90.7-114.4	102.2 ± 1.20	5.87 ± 0.847	5.7 ± 0.8	
Head	Male	105-133	119.1 ± 3.33	10.0 ± 2.36	8.4 ± 2.0	119
	Female	120-147	127.9 ± 2.21	8.54 ± 1.56	6.7 ± 1.2	123
	Pooled	105-147	124.6 ± 1.73	8.46 ± 1.22	6.8 ± 1.0	
Trunk	Male	240-278	253.0 ± 3.41	10.2 ± 2.41	4.0 ± 1.0	219
	Female	234-279	263.7 ± 4.21	14.7 ± 2.68	5.6 ± 1.0	246
	Pooled	234-279	259.7 ± 2.75	13.5 ± 1.95	5.2 ± 0.8	
Tail	Male	590-646	624.9 ± 4.93	14.8 ± 3.49	2.4 ± 0.6	661
	Female	591-640	608.7 ± 3.20	12.4 ± 2.26	2.0 ± 0.4	631
	Pooled	590-646	614.8 ± 3.14	15.4 ± 2.23	2.5 ± 0.4	
Head in trunk	Male	1.84-2.42	2.09 ± 0.0554	0.166 ± 0.0392	8.0 ± 1.9	1.84
	Female	1.69-2.30	2.06 ± 0.0405	0.157 ± 0.0286	7.6 ± 1.4	1.99
	Pooled	1.69-2.42	2.07 ± 0.0331	0.162 ± 0.0234	7.8 ± 1.1	
Trunk in tail	Male	1.12-2.66	2.47 ± 0.0488	0.146 ± 0.0347	5.9 ± 1.4	3.01
	Female	2.11-2.86	2.42 ± 0.0625	0.242 ± 0.0441	10.0± 1.8	2.57
	Pooled	2.11-2.86	2.44 ± 0.0430	0.212 ± 0.0307	8.7 ± 1.3	
Eye in snout	Male	2.63-3.68	3.20 ± 0.119	0.356 ± 0.0839	11.1± 1.7	3.62
	Female	2.68-3.50	3.13 ± 0.0647	0.251 ± 0.0458	8.0 ± 1.5	3.30
	Pooled	2.63-3.68	3.16 ± 0.0605	0.296 ± 0.0428	9.4 ± 1.4	
Snout in head	Male	1.87-2.58	2.17 ± 0.0667	0.200 ± 0.0472	9.2 ± 2.2	2.06
	Female	1.93-2.36	2.12 ± 0.0302	0.117 ± 0.0214	5.5 ± 1.0	2.05
	Pooled	1.87-2.58	2.14 ± 0.0311	0.152 ± 0.0220	7.1 ± 1.0	

was also at this time in communication with Mr Dawson, at present engaged in a revisionary study of *Lissocampus* and allied genera, and the specimen noted above and with two others were forwarded to him for examination. Mr Dawson has identified these as the species currently known as *Ichthyocampus runa* Whitley, 1931, and has courteously agreed to a report of the Tasmanian occurrence of this species (a Tasmanian example of which from Wineglass Bay (Thouin Bay), east coast, has already been examined by him) being incorporated in the present contribution, which, drafted while Mr Dawson's paper is in the late MS stage, is expected to postdate it in publication.*

It may be noted in passing, that in the typed list of errata and emendations in the South Australian catalogue of Scott *et al.*, circulated in April 1976, the inclusion of a record for Tasmania of *Lissocampus affinis* Whitley, 1944 is an error, being a slip for *L. caudalis* Waite and Hale, 1921, reported from this State in Part X (1961, fig. 3) and Part XVIII (1971, p. 125).

* Added in press. C.E. Dawson. *Proc. Biol. Soc. Wash.*, 89 (53), 599-620. 1977.

Material. Three specimens collected by Mr R.H. Green in the Queen Victoria Museum's collection: (*a*) *Ls* 34.0, *Lt* 34.9, Greens Beach, north coast, 24 April 1976, Reg. No. 1976/5/142; (*b*) *Ls* 69.0, *Lt* 70.5, 3 km north of Greens Beach, 24 March 1976, Reg. No. 1976/5/93; (*c*) *Ls* 81.1, *Lt* 83.0, 2 km north of Greens Beach, 18 February 1976, Reg. No. 1976/3/131.

Meristic characters. Annuli 13 + 45-48. Subdorsal annuli 1 + 2. D. 12. P.6. A.6.

Proportions. Head in total length 10.9, 12.8, 13.6. Snout 3.0, 2.9, 2.9 in head. Eye 6.4, 6.5, 6.8 in head, 2.1, 2.2, 2.3 in snout. Head 2.13, 2.91, 2.56 in trunk. Precaudal length 2.49, 2.91, 2.82 in tail. Trunk 3.66, 4.18, 3.93 in tail. Dorsal base 3.2, 2.8, 2.7 in head. Depth of body 31.7, 35.3, 26.8 in *Lt*, 2.9, 2.8, 2.0 in head. Depth of head 24.4, 33.6, 24.4, in *Lt*, 2.3, 2.6, 1.8 in head.

Coloration. When examined shortly after capture (*c*) was a virtually uniform bright sulphur yellow, with small but conspicuous markings as follows (all unless otherwise specified lively red-brown, deepest on head): on middle side of trunk immediately behind head a whitish spot annulated with reddish, followed by 7-8 pairs (sides differing) of spots, one near upper one near lower border, the first 5-6 pairs marking out the first 5-6 annuli, the next well separated; on ventral surface of trunk a median line of short strokes and an arc embracing front of vent; on ventral surface of tail in each annulus a spot close to either border; other surfaces of trunk, tail immaculate; on lateral surface of head a subvertical, slightly proconcave bar about bisecting operculum, two spokes from eye to ventral profile, first, at 7 o'clock (left side viewed), divaricating and expanding somewhat below, second, at 4 o'clock, extending about to operculum, a small spot near lower end of snout; on ventral surface two pairs of spots, a median hyphen between them, a deep arc joining the ends of the hinder spoke from eye, a brief continuation of the opercular marking; on dorsal surface a faint proconcave arc between posterior borders of eyes. After preservation, ground colour whitish, markings much as before, dorsal colorless, caudal very pale brownish, pectoral (minute) whitish.

Chief variations exhibited by (*b*): trunk and tail markings, though similar, somewhat less pronounced; lateral surface of head with anterior spoke a simple line, posterior spoke more curved, briefly interrupted near lower end; an additional spoke, very short, up and back from 1 o'clock; opercular bar reduced to a short stroke, no spot at end of snout but one at middle of lower border; on ventral surface two spots and a posterior transverse arc on snout, a transverse arc right across postorbital head, a short oblique stroke on branchiostegal border; on dorsal surface a spot at hind angle of orbit, median spot on occiput, spot at middle of operculum; dorsal light brownish, caudal with obscure spots and short longitudinal strokes of reddish brown. Specimen (*a*) differs from (*b*) and (*c*) mainly in possessing a distinct dark bar across ventral surface of snout, continuing halfway up lateral surface, and in having proximal one-third of caudal dark brownish.

Tentacle. 'There is a small tubercle over the eye, and another on the occiput, besides several minute ones scattered over the upper part of the head' (McCulloch 1909, p. 319). A small subcylindrical supraorbital tentacle was present in one specimen; no other appendages were observed.

Syngnathus poecilolaemus Peters, 1869

Syngnathus poecilolaemus Peters 1869, *Monatsb. Akad. Wiss.*, Berlin (1868), p. 458.
Type locality: Adelaide, South Australia (Schomburgk).
Corythoichthys poecilolaemus McCulloch, 1929, *Mem. Aust. Mus.*, 5 (1), p.87.

Proportions. Though Waite and Hale in their review of South Australian lophobranchiates (1921) observed they had 13 males and 11 females before them, they gave the conventional

body ratios for one individual only: these single variates have since become adopted, without amplification, in general works such as the Handbook (Munro 1958) and the South Australian catalogue of Scott *et al.* (1974). In a paper on the first Tasmanian example, *Ls* 185.0, *Lt.* 188.5, from Kelso, north coast (Scott 1968) values of these ratios were recorded. In a note added after the paper's completion mention was made of a second individual, collected between Flinders Island and Clark Island: apart from standard length 122.5 and total length 129.8 no dimensions were published.

The principal body ratios for the Bass Strait example, together with those for the Kelso example (in parentheses Waite and Hale's values where available) follow. Head in trunk 1.5, 1.7 (1.4), in total length 6.3, 7.0 (7.4); trunk in tail 2.4, 2.6 (2.4); snout in head 1.8, 1.7 (1.75); eye in snout 5.3, 5.3 (4.5), in head 9.6, 9.0 (8.0); interorbital 1.3, 1.5 in eye. Length to pectoral origin 6.18, 7.03, to dorsal origin 2.57, 2.73, to dorsal termination 2.12, 2.22, to vent 2.47, 2.62 in *Lt.* Longest pectoral ray 6.9, 6.6, longest dorsal ray 4.7, 5.1 in head. Greatest width 1.2, 1.2 in greatest depth.

Annuli 20 + 45; subdorsal from 0.9 of penultimate trunk to 0.7 of 6th caudal (7.7 annuli). D. 27. P.13. A. 3. C.?8.

Family LAMPRIDAE

Genus *LAMPRIS* Retzius, 1799

Lampris Retzius, 1799, *K. Vet. Akad. Nya.*, Stockholm, 20, p.97. Type-species, *Zeus guttatus* Brunnich = *Zeus regius* Bonnaterre (*fide* Jordan, GEN. FISH.).

Lampris regius (Bonnaterre, 1788)

Zeus regius Bonnaterre, 1788, *Tabl. Encycl. Meth., Ichth.*, p.72. Type locality: Torbay, England (Pennant, BRIT. ZOOL.).
Zeus luna Gmelin, 1789, SYST. NAT. (Linné), ed. 13, 1, p.1225. Type locality: 'In mari Normanniam' (Duhamel).

Tasmanian records. As noted in Part IX (1960, p.90), Australian records of the opah, moonfish or mariposa are few, a survey by Whitley (1950) listing 5 [Western Australia 1, Victoria 2, Tasmania 2): there are, however, 10 entries for New Zealand in the period 1882-1950. Later Whitley (1962, p.62) added New South Wales to the Australian distribution and the species has now been reported from South Australia (Scott *et al.* 1974). It is clear this beautiful pelagic fish (the sole representative of its family) though widely distributed is rare (or, at any rate, rarely encountered) in the southern hemisphere; Smith (1950, p.141) noted only two records in Southern Africa and Munro (1955) did not include it in his Ceylon catalogue.

Three Tasmanian examples have so far been noticed in the literature: (*a*) near Port Arthur, south-eastern Tasmania (first Australian example), December 1895, 1.07 m to caudal base, 1.09 m to middle of caudal, weight 54.4 kg; (*b*) Storm Bay between Bruny Island and Tasman Peninsula, 1936; (*c*) Bridport, north coast, August 1943, *Ls* 1001 mm, *Lt* 1056, weight approximately 45 kg. Some details of these occurrences (with in the case of (*c*) meristic and morphometric data and notes on coloration) have been given in Part IX (1960). For (*a*) see also Morton (1897), Lord and Scott (1924), Whitley (1929). For (*b*) Whitley (1950) notes approximate length, and cited *The Advocate* 1/12/36. By courtesy of Mr D.J. Cherry, the present editor, a photocopy of the report has been made available from the newspaper's files. This notes the fish 'was recently found floating on the surface of the water in Storm Bay by a Hobart fisherman. It was apparently sick and was easily got on board'. It was about four feet [1.2 m] long and nearly as deep, while its width was a little more than a foot.

Attention is here called to three further reports: (*d*) Robbins Island, off the north coast; first seen by Smithton pilot Mr H.G. Vincent on one of his regular island-hopping flights; stated to be 1.3 m long, approximately 1 m deep, 380 cm 'across the back'; saucer-like eyes 100 mm in diameter; a photograph in *The Advocate* of 13 January 1976 provides a good picture of the fish and makes possible a satisfactory specific determination. The newspaper account included reports by Smithton naturalist Mr B.H. Wragge of two other examples: (*e*) Perkins Island, off the north coast, picked up on the beach about ten years ago; (*f*) Seven Mile Beach, about five years ago.

Variation. A comparison of *(i) The Advocate* photograph of (*d*), *(ii)* a photograph of (*a*) made available from R.M. Johnston's ichthyological memoranda by Whitley (1929, pl. 2, fig. 2) and illustrations provided by *(iii)* Günther (1880 , fig. 203), *(iv)* Kershaw (1913, pl.6), a Victorian example, total length 1.09 m [Kershaw noted this fish as affording the first Australian record, having overlooked the 1895 Tasmanian specimen]; *(v)* Munro (1957, fig. 447), *(vi)* Scott *et al.* (1974, fig. on p.97), a South Australian example 1.8 m long stranded near Kingston in 1963 reveals some noticeable differences, particularly in the shape and degree of development of some of the fins.

In *(i)*, *(ii)*, *(iii)*, *(v)*, the pectoral is slender — least so in *(iii)* — falciform, subequal in length to head; in *(iv)* similar in shape, but only about two-thirds head; in *(vi)* short, subequal to snout, very different in form, almost as broad as long, inferior border apparently about two-thirds (instead of from about one-fourth to one-third) superior border. The pelvic is in general subequal in length to pectoral, and equal to, or somewhat less than, width of outspread caudal; characteristically narrow falcate — most noticeably so in *(i)*, *(iii)* — but broader, but distally obtuse in *(vi)*, somewhat blunt distally in *(ii)*, but possibly imperfect here. The caudal is commonly lunate — most pronouncedly so in *(i)*, *(iii)*, tips of lobes extending behind median rays by a distance subequal to length of latter — but is only slightly excavate in *(iv)*: in *(iv)*, *(v)*, *(vi)* posterior caudal border shows some indication of being sinuate. The position of insertion of pelvic is not satisfactorily determinable in *(i)* in others, except in *(vi)* in which it is under, or barely in advance of, dorsal origin, it is located under elevated anterior portion of that fin.

Family SCORPIDAE

The three Tasmanian species of the genus *Scorpis* — *S. georgianus* Valenciennes, 1832, *S. aequipinnis* Richardson, 1848, *S. lineolatus* Kner, 1865 — have been keyed in Part XVII (1970, p. 45); criteria for separating off *Atypichthys strigatus* (Günther, 1860), first reported from this State in Part XX (1974b, p. 180), are given in that paper. Other references to Scorpidae in these Observations are to be found in Part II (1935), Part XVII (1970), Part XXII (1976). Two jüvenile examples of *S. aequipinnis* here noted provide some interesting observations on early coloration and on relative growth.

Genus *SCORPIS* Valenciennes, 1832

Scorpis Valenciennes, 1832, *in* Cuvier and Valenciennes, HIST. NAT. POISS., 8, '1831', p. 503. Type species, *Scorpis georgianus* Valenciennes.

Scorpis aequippinnis Richardson, 1848

Scorpis aequipinnis Richardson, 1848, ZOOL. VOY. EREBUS AND TERROR, FISH, p. 121. Type locality: King George's Sound, Western Australia.

Material. Thirteen specimens, here listed in order of ascending magnitude of standard length; registration numbers are those of the Queen Victoria Museum Launceston. (*a*) *Ls* 40.0, 2 km north of Greens Beach, north coast, 18 April 1976, R.H. Green, Reg. No. 1976/5/125; (*b*) 44.0, same history as (*a*); (*c*) 112.0, Shear Reef, Low Head, north coast, 27 January 1973, R.L. Askeland, 1973/5/57; (*d*) 120, Bicheno, east coast, 21 April 1973, Scuba Club, 1974/5/79; (*e*) 133, 3 km east of Wynyard, north-west coast, 7 January 1973,

Scuba Club, 1973/5/16; (*f*) 152, same history as (*d*); (*g*) 155, Albatross Island, Bass Strait, 21 January 1973, D. Milledge, 1973/5/39; (*h*) 162, same history as (*d*); (*i*) 165, same history as (*g*); (*j*) 196, Coles Bay, east coast, 7 April, 1973,—, 1973/5/89; (*k*) 230, Bicheno, east coast, 21 April 1973, Scuba Club, 1974/5/74; (*l*) 231, Stanley, north-west coast, November 1974, M. Hardstaff, 1975/5/5; (*m*) 238, same history as (*k*).

Dimensions of juveniles. Dimensions of (*a*) and (*b*) are given as permillages of standard length; smaller individual first. Total length 1313, 1316. Length to origin, termination of first dorsal 358, 389, 575, 666; of second dorsal 600, 682, 865, 909; of anal 505, 591, 868, 910. Length to pectoral, at front of base 250, 273, at origin of longest ray 290, 295; longest (3rd, 3rd) ray 260, 252. Length to ventral 363, 432; length of longest (4th, 4th) ray 160, 166. Length to vent 498, 545. Head 313, 341. Snout 675, 795. Eye 120, 114. Interorbital 105, 107. Anal spines 75, 61; 90, 80; 103, 91. (Lengths of spines, *L*, are specifiable in terms of serial number of spine (*N*) by the formula $L = bN^k$, the parameters, with absolute length in mm, being *k* 0.3596, 0.2820, *b* 2.7075, 2.9901; *t* = 30.33*, 18.18*). Longest (5th, 6th) dorsal spine 110, 107. Longest (3rd, 3rd) dorsal ray 165, 159. Longest (2nd, 2nd) anal ray 155, 159. Depth at front of eyes 200, 211, back of eyes 353, 352, operculum 498, 432, vent 482, 523; maximum depth 498, 534; depth of caudal peduncle 115, 114.

Relative growth. A comparison of relative (*TLs*) dimensions of the two juveniles, (*a*), (*b*), *Ls* 40.0, 44.0, with those of two adults, (*g*), (*l*), *Ls* 196, 231, showed in a number of cases a noticeable disparity between the two groups. To determine whether these differences held good with a larger adult and subadult sample measurements were made of the additional individuals specified above. Clear evidence of differential relative growth was found in ten dimensions, the juvenile and non-juvenile sets being disjoint in four of these. In each of the next ten paragraphs the first line gives (in this sequence and style) the following data, all entries as permillages of standard length; (*a*), (*b*); range for (*c*)-(*l*), mean for (*c*)-(*l*) with standard error; correlation *r* (*z*) of dimension and *Ls*; *t*, followed by one, two, three asterisks, denoting significance at P 0.05, 0.01, 0.001, respectively. Coefficients of variation, *V*, and medians recorded are all those of the sample (*c*)-(*l*).

(i) Head. 313, 341; 261-297, 278.9 ± 3.32; — 0.571 (0.649); 2.31*. The non-juvenile sample for head exhibits a good measure of constancy (*V* 4.0), and is tolerably symmetrical, with median 278.

(ii) Eye. 120, 114; 60-80, 69.1 ± 2.15; — 0.914 (1.551); 8.04***. A negative correlation for eye (*TLs*) and *Ls* is frequently encountered. Distribution of (*c*)-(*l*) is negatively skew (median 72); variability being rather large (*V* 10.3). The correlation of eye, as permillage of head, with head, absolute, is —0.876 (1.359); *t* 9.73***.

(iii) Length to ventral origin. 363 432; 273-340, 310.4 ± 6.13; — 0.660(0.792); 2.91*. *V* 6.6, median 311.

(iv) Depth at back of eyes. 353, 352; 247-353, 302.9 ± 8.35; —0.642 (0.762); 3.18**. *V* 9.1, median 303. Of five other depth measurements — at front of eyes, operculum, vent, caudal peduncle, maximum — all showed a negative, but not formally significant, value of *r*. There is very marked individual variation within each set of dimensions. Specimen (*a*) contributes some four-fifths, nine-tenths of total positive *dxdY* for depth of vent, maximum depth, respectively, while (*b*) provides seven-tenths for opercular depth. A general tendency to a negative correlation of depth with length is further evidenced by the fact that, with specimens of the subadult-adult sample arranged in ascending order of magnitude of *Ls*, in all cases, except at front of eyes, the mean value for the first half of the series exceeds that for the second half.

(v) Longest pectoral ray. 260, 252; 174-227, 193.8 ± 4.76; —0.814 (1.138); 4.64***. *V* 8.1, median 188. In most of our material the pectoral is longer than as

shown in the figure in Scott *et al.* (1974, p.250), reaching in each of the two juveniles to the second anal ray, and among the others to anal origin (1 specimen), vent (5), short of vent by distance equal to (2), half (3) interval between vent and anal origin.

(vi) Longest ventral ray. 160, 166; 130-172, 146.5 ± 3.73; −0.739 (0.949); 3.64**. *V* 8.4, median 142. The longest ray is regularly the fourth (second from spine). In all our examples the ventral is decidedly longer than depicted in the figure just mentioned, reaching in (*a*), (*b*), to vent, first anal spine, respectively. and among the others to anal origin (1), vent (6), short of vent by distance equal to total (2), to half (2) interval between vent and anal origin.

(vii) Ventral spine. 75, 70; 59-92, 71.6 ± 3.43; −0.566 (0.641); 2.28*. *V.* 15.9, median 67.

(viii) First anal spine. Data for 9 specimens only, spine imperfect in (*d*), (*g*), (*i*), (*k*). 75, 57; 24-58, 45.4 ± 5.45; −0.833 (1.195); 4.99** (d.f. 7). *V.* 31.7, median 50.

(ix) Second anal spine. 90, 80; 42-86, 64.0 ± 5.08; −0.813 (1.137); 4.64***. *V* 19.3, median 65.

(x) Third anal spine. 103, 91; 60-96, 77.2 ± 3.57; −0.831 (1.192); 4.96***. *V* 15.3, median 76.

It is to be noted the coefficients of variation for the anal spines and the ventral spine are large (the only cases reaching double figures). However, the distribution as measured by the number of entries (7; with d.f. 7; 8, 7) within one standard deviation on either side of the mean is normal or virtually so.

Among other measurements made, positive correlations not significant at P 0.05 were found for longest dorsal ray (0.170), longest anal ray (0.274): in both cases, however, adult mean noticeably exceeds juvenile mean, though with adults arranged in ascending order of magnitude of *Ls* the mean of the first five specimens is greater than that of the last five; individual variation is great, the adult range for dorsal rays being 157-250, for anal rays 171-259. Non-significant negative correlations characterize length to dorsal origin (−0.180), length to anal origin (−0.139), length to pectoral origin (−0.486), length of longest dorsal spine (−0.492), interorbital (−0.366): in all cases the juvenile mean exceeds the adult (barely so in length to dorsal), and with specimens in order as before the first mean exceeds the second in length to dorsal origin, length to pectoral origin. Dimensions in which both the relative value of young and adult and the relative value of first and second halves of the adult sample (each 5 individuals) show the same sense of correlation as that of the whole sample quite probably would be found, on investigation of a more extensive series, to exhibit statistically significant correlation with length of fish of the appropriate sign.

Non-metrical juvenile features. The juvenile examples differ from the non-juvenile not only in respect of the metrical features considered above, but also in coloration (treated separately below) and in several points of general appearance.

A striking feature of a sizable example of this species is shortness of the exposed, as compared with the total, length of the dorsal spines. The concealment of the proximal portion is not primary attributable to the presence of a basal sheath of scales, though scales do ascend on to the fin, but is brought about by a thick fleshy covering in the form of an upward extension of the general integument, its distal border effectively constituting part of the overall profile of the body. In the juveniles the whole appearance of the fin is quite different, the spines standing more or less erect, and though provided with a thin squamous sheath, being clearly traceable

throughout their entire length. The spinous dorsal of the young *Scorpis aequippinis* thus has much the same character as that of the mado, *Atypichthys strigatus* (Günther, 1860).

Coloration. While adult and subadult fish, as preserved, are largely uniform brownish black above, lighter below, with the fins, except for, in many individuals, a narrow light hind border to the caudal, more or less concolorous with the body, the small examples exhibit a distinct, more diversified, juvenile pattern.

General colour of trunk and tail olivaceous above lateral line, silvery below; liberally sprinkled with small melanophores, distinctly larger in a band extending about equally on either side of lateral line, its width subequal to distance of lateral line from dorsal profile anteriorly; a conspicuous black spot on body at upper angle of pectoral lobe, just extending on to rays. Head olivaceous, darkest on occiput; an irregular silvery patch below eye. First dorsal olivaceous. Second dorsal largely olivaceous; briefly dusky at distal border anteriorly; behind a line from near middle of distal border to near posterior end of base white. Anal largely olivaceous, narrowly blackish along anterior border; this strip in contact with a blackish pennon extending along anterior half, or more, of outer edge; behind an arc from near tip of pennon to base of fin white. Pectoral pale yellowish green. Ventral, inner one-third very pale yellowish green, rest blackish. Caudal chiefly light olivaceous; a whitish terminal lunule involving about middle half of the falcate posterior border and extending back in its greatest (mesial) extension about one-fourth of way to base; upper and lower borders very sharply delimited by narrow black bands. The color pattern of the caudal bears no similarity to that of the adult, and is both striking and curious — the black flanking strips, markedly different in intensity of colour from the rest of the fin, appear like two diverging black rods standing out, on casual observation, almost as isolated structures with little if anything spread between them.

Family LEPTOSCOPIDAE

Of the two genera recorded from Australia, *Crapatalus* Günther, 1861 and *Leptoscopus* Gill, 1860, each with a single local species, only the former is known to occur in this State, an example of *C. arenarius* McCulloch, 1915 from Greens Beach, north coast, being the subject of some general observations in Part XVIII (1971, p. 139); a second example seen at the same time escaped capture. The species is said not to be common — McCulloch's material comprised only three examples, and Scott *et al.* (1974) stated only three had been recorded from South Australia; however, in recent months upwards of a score have come under the writer's notice. Fish from southern and eastern Tasmania exhibiting some differences from typical *Crapatalus arenarius* as described and figured by McCulloch and as represented by the 1971 northern Tasmanian specimen are here described as a new subspecies.

Genus *CRAPATALUS* Günther, 1861

Crapatalus Günther, 1861, *Ann. Mag. Nat. Hist.*, 3 (7), p. 86. Type-species, *Crapatalus novaezelandiae* Günther.

Crapatalus arenarius McCulloch, 1915

Crapatalus arenarius McCulloch, 1915, *Proc. Linn. Soc. N.S.W.*, 40 (2), p. 269, pl. 37, fig. 1. Type locality: Narrabeen, near Sydney, New South Wales.

Crapatalus arenarius lasti subsp. nov.
(fig. 1)

Type-specimens. Holotype (*e*) standard length 80.2 mm. total length 90.6, 4 paratypes, (*a*) 44.0, 50.3, (*b*) 48.5, 55.5, (*c*) 53.0, 60.4, (*d*) 54.0, 62.6; Blackmans Bay, south-

eastern Tasmania, March 1976, Mr P.R. Last; Queen Victoria Museum Launceston Reg. Nos. holotype 1976/5/200, Q.V.M. Type No. 228; paratypes 1976/5/201 *a-d*, Q.V.M. Type Nos. 229 *a-d*.

Since the description based on the type-specimens was drawn up further examples, all collected by Mr Last, have become available for examination. These extend the ranges for some meristic characters: the values for the new material are shown in square brackets. Additional material: Blackmans Bay, 4 specimens, *Ls* 36.0-79.0, 3 April 1976, 3 specimens, Nine Mile Beach, Swansea, east coast, *Ls* 50.2-72.3, 4 September 1976, 10 specimens, Nine Mile Beach, Swansea, *Ls* 53.0-76.1, 6 November, 1976.

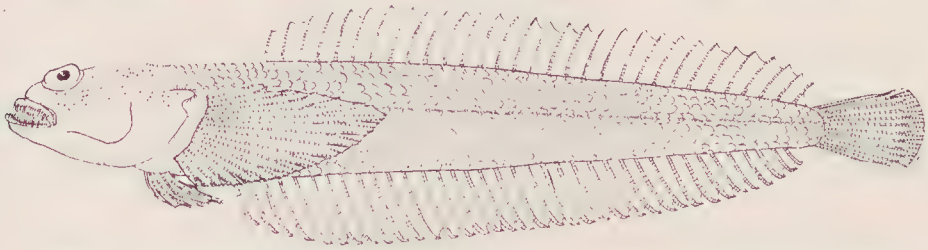

FIG. 1 - *Craptalus arenarius lasti subsp. nov.* Holotype, standard length 80.2 mm, total length 90.6 mm, Blackmans Bay, south-eastern Tasmania; Queen Victoria Museum Reg. No. 1976/5/200, Type No. 228 : x 1½.

Diagnosis. Differs from the nominate species as follows: no exposed spines on breast; anal distinctly higher than (*cf.* equal to or slightly lower than) dorsal; caudal lacking produced ray, the uppermost main ray being equal to, or shorter than, the ray immediately below it.

Description. The definitive datum relates to the holotype, data in parentheses to paratypes in ascending order of standard length; ranges for additional material in square brackets. Basic measurements are set out in table 3.

Br. 6. D.31 (33, 33,33,31) [32-34]. A.37 (35, 35, 36, 40) [34-36]. P.17 (16, 17, 17, 17) [17-21]. V.I,5. C. 2+10+2. L.lat.43 (44, 42, 42, 41) + 1 on caudal in each case: on right side of holotype a second, abnormal tubercle on caudal extending half length of fin, its length thrice that of a normal tubercle [44-47]. L.tr. 5/1/5.

Head 4.2 (3.8, 3.8, 3.9, 4.0) in *Ls*. Maximum depth of body 8.2 (8.5, 6.7, 6.6. 7.8) in *Ls*, 1.9 (2.3, 1.8, 1.7, 2.0) in head; depth at vent 6.7 (7.3, 5.9, 7.6, 8.0) in *Ls*, 1.6 (2.0, 1.5, 1.9, 2.0) in head. Eye 6.8 (6.8, 6.7, 7.1, 6.7) in head, 1.07 (0.59,0.53, 0.79, 1.07) in interorbital, 1.5 (1.4, 1.4, 1.3, 1.1) in snout. Depth of caudal peduncle 1.6 (1.4, 1.6, 1.6, 1.4) eye, 6.8 (4.9, 4.2, 4.4, 4.7) in head. About longest, 7th, dorsal ray 3.3 (3.5, 4.0, 3.5, 3.5) in head, 1.2 (1.2, 1.3, 1.2, 1.2) in 7th anal ray. Longest, 5th-6th, pectoral ray 1.0 (1.2, 1.1, 1.0, 1.0); longest, 4th, ventral ray 1.8 (2.6, 2.2, 2.2, 2.1); ventral spine 4.8 (4.7, 4.7, 4.5, 4.0); caudal fin 1.8 (1.8, 1.8, 1.8, 2.1) in head.

Head depressed, nearly flat above, moderately rounded below. Trunk and tail compressed, latter evenly tapering. Head wholly naked. Body covered with large cycloid scales, extending forward on dorsal surface about halfway between dorsal origin and tip of snout, on lateral surface to pectoral base (itself naked) on ventral surface to, but not on to, ventral fin base; extending back briefly in an arc of 1 laterally, 2-3 mesially on to caudal; subequal except above, and briefly laterally, in advance of dorsal, here smaller. Lateral line sloping down, virtually straight, for a distance subequal to postorbital head, thereafter horizontal; tubules hemicylinders slightly expanded, with some indication of very brief bifurcation, at posterior end, modally

extending across whole scale, crowded anteriorly, first one-fourth of series in about one-sixth of its length. No exposed spines on breast (*cf.* Affinities, below). Urinogenital apertures in an ovoid elevation immediately in advance of anal fin, its wall plicate, crenulate, particularly anteriorly; a minute papilla, fully exserted in paratype (*c*) as a digitiform process, length subequal to width of adjacent anal ray, arising from, or proximally in contact with, a mammilliform elevation.

Lower jaw projecting beyond upper. Mouth at an angle of approximately 40° to horizontal; maxillary extending back to below 0.5 eye (0.4, 0.2, 0.4, 0.7). Both lips with a row of slender, acuminate, inwardly curved cirri, regularly decreasing in size outwards, length of longest about half eye; in lower jaw free, extending whole length of lip, 45 (42, 39, 40, 47); in upper jaw free mesially, either absent or invisible in gelatinous matrix near angle of mouth, countable 28 (28, 33, 26, 30): with mouth closed tips of cirri briefly interlock. A curved line of 15 (12, 14, 8, 14) similar to, but somewhat shorter than, labial cirri fringing upper part of operculum, anterior two-thirds of series directed up, or up and somewhat back, the rest curving markedly to point down, or down and forward; several of the uppermost usually more or less embedded in gelatinous material. Eye superolateral, but wholly visible from above, its least distance from ambitus little less than interorbital; distant from preorbital margin by rather less than its diameter. Interorbital slightly concave (almost flat in several paratypes). Anterior nostril tubular, decreasing in height obliquely forward and outward, set in subcircular concavity about equidistant from orbit and preorbital border. Posterior nostril subcylindrical, somewhat compressed distally, partly externad of anterior, hard against orbit, slightly larger and higher (in some paratypes apparently lower) than anterior. Preopercular margin rounded, entire; in advance of its margin, skirting its whole length and continuing forward into lower jaw the subjacent operculomandibular canal of the lateral line system, giving off a dozen equally spaced radiating tubules, each with one or two (at angle three) pores, four more tubules in mandible: lateral canal also traceable, zigzag to eye, in advance of this in paratypes portions of supraorbital and infraorbital canals apparent, the latter with one or two genal offsets. Operculum without spines, thickened above, thin, more or less membranous below: from shortly below the opercular cirri, through an arc subequal to that they beset, border delicately crenulate.

Teeth in jaws minute, cardiform, depressible; in up to three rows in front, narrowing behind to one; greatest width of band subequal to length of adjoining labial cirri. About twelve-fifteen teeth on anterior half or less of each palatine, some anteriorly in two imperfect rows. A small group of half a dozen cardiform teeth on each side of vomer, separated by an interval wider than one series. Visible surfaces of pharyngeal bones covered with villiform teeth.

Dorsal originating about above middle of pectoral, above 4th (4th-5th) anal ray, behind head by 0.34, (0.28, 0.26, 0.27, 0.32) head, attached by membrane to caudal peduncle almost at level of hypural joint, base (ray-ray) 1.54 (1.60, 1.53, 1.59, 1.57) in *Ls*; composed wholly of simple rays slightly flattened and expanded distally, tips free, increasing in length to about 7th, showing scarcely any diminution through first half of fin, thereafter slowly decreasing. Anal similar to dorsal, originating about below anterior one-third of pectoral, attached by membrane barely beyond (at or virtually at) level of hypural joint, base (ray-ray) 1.46 (1.47, 1.49, 1.48, 1.47) in *Ls*; composed wholly of simple rays similar to, but longer than, those of dorsal, 7th anal ray 1.2 (1.3, 1.3, 1.2, 1.2) 7th dorsal ray. Pectoral large, total length 1.3 (1.1, 1.2, 1.2, 1.1) head; longest, 7th (6th-7th) ray 0.95 (0.80, 0.95, 0.96, 0.87) head, rays above this becoming somewhat abruptly shorter, those below decreasing evenly; first (uppermost) ray simple, next five bifurcate for half their length, rest with the upper ramus of the primary dichotomy giving off from near its base a secondary ramus that keeps close to it; rays tips free. Ventral inserted in advance of pectoral, about under preopercular border, extending almost horizontally outward, rather rounded, ray next to spine simple, other rays markedly bifurcate; interval between fins two-thirds

length of fin. Caudal rounded, neither uppermost nor lowermost of main rays (both single) reaching nearly as far back as median rays; no produced ray.

Coloration in formalin. (*a*) *Holotype.* Trunk and tail above lateral line pale greenish, in places with some hints of brown, most of the scales with several large and many small melanophores, most abundant and intense beside dorsal base; below lateral line, including ventral surface, whitish, immaculate save for a row of minute black spots one on each of most scales flanking anal base, and for a few small obscure dark markings elsewhere on lower flank. Head above a line from near angle of mouth to tip of opercular lobe greenish or greenish brown with thickly set dark brown chromatophores, dark bluish transversely elliptical patch on occiput, small cluster of minute brown spots round mandibular symphysis, extending on left side only as narrow strip along lower lip; rest of head pale greenish, immaculate. Dorsal rays in anterior half of fin pale green each with two groups of dark brown chromatophores, in posterior half most punctulated, wholly or in most part, with brownish; membrane hyaline, immaculate. Anal immaculate, rays whitish, membrane hyaline. Pectoral mostly pale greenish, several lower rays purplish brown distally. Ventral whitish proximally, purplish brown in distal half or less. Caudal greenish in proximal one-third, thereafter brown with some hint of purple.

(*b*) *Paratypes.* Dorsal rays show variation as follows: brown or golden brown in anterior two-thirds, lighter behind, some with one or more darker patches; half a dozen more or less equally spaced rays silvery, rest tipped or briefly banded brownish; mostly brownish olivaceous, becoming somewhat lighter behind; first one-fourth rather dark brownish, lighter behind, with, in places, bronze tinge. Anal rays range from white to very pale brownish, tending to become a little deeper distally. Pectoral and ventral vary in extent of purplish area. Caudal with somewhat variable amount of brownish, one specimen tipped very dark brown.

Size. *Crapatalus arenarius* is a small fish, the 'length' of McCulloch's type being noted as 85 mm, *Ls* and *Lt* of the 1971 northern Tasmanian specimens being 75.9, 85.6, and the conventional length given by Scott *et al.* 9 cm. The standard length of the 22 specimens here noted is 36.0-80.2, $\bar{x}$ 59.2 ± 2.61, the total length 41.0-90.6, $\bar{x}$ 67.0 ± 2.97. The *Ls* frequency distribution in 12 length classes 35.5-37.4 ... 77.5-81.4 is 1, 1, 2, 2, 4, 1, 1, 5, 0, 2, 2, 1.

Affinities. *Crapatalus arenarius lasti* is much similar in general facies to the nominate subspecies, the most notable differences being those set out above in the diagnosis.

McCulloch reported and figured 'breast armed with two small spines which project forward': in the 1971 account of the northern Tasmanian specimen attributed to the typical species it was noted the spines were less developed than seemed to be indicated by the figure of tye type; they are, indeed, minute. No exposed spines are present in any of the type-specimens of *C. a. lasti* or in any of the additional examples examined. The relevant region in the holotype differs somewhat from that in the paratypes. In the holotype a subtriangular area, slightly wider than long, extends forward from the ventral bases as a median tumescence, rounded laterally, its top followed, at a lower elevation, by a slender rod, rather more than half an eye diameter in length, apparently bifurcated briefly at its anterior end, and flanked on either side by a sigmoidal fleshy fold originating near ventral base. In the paratypes the pre-fin subtriangular area may resemble that in the holotype, may present an almost flat face, or may include a smaller subtriangular elevation, the apices common; beyond the apex, generally the most elevated point on the whole system, and in most cases somewhat rostriform, the isthmus continues forward more or less in the form of a semipyramid, the sides somewhat concave, the free border slightly or markedly convex dorsad. Partial dissection at the elevated apex of the triangle in a paratype, (*b*), reveals the presence of a single small broad acute spine, previously totally embedded and quite invisible.

The anal, in the nominate subspecies equal to or a little lower than the dorsal, is here distinctly the higher fin; the 7th anal ray, noted by McCulloch as equal to, and being in the 1971 northern Tasmanian fish very slightly less than, the 7th dorsal ray, is here 1.21-1.49, $\bar{x}$ 1.31 ± 0.0456 it: the anal is regularly higher than the dorsal also in the additional material. In *C. a. arenarius* as described and figured by McCulloch the uppermost main caudal ray is produced slightly beyond the general border of the fin, and this is the situation also in the northern Tasmanian fish: in *C. a. lasti* this ray is not produced and may be shorter than the ray immediately below it. In the Tasmanian example of the nominate subspecies length to ventral is 138 *TLs* (no exact data available for types): in the types of the present subspecies the *TLs* value is 159-179, $\bar{x}$ 165.8 ± 4.58; for 17 other examples 165-197, $\bar{x}$ 176.9 ± 1.50.

The present fish show some differences in coloration from the types of *C. a. arenarius*, fins in which are described as colorless, but here bear some markings. However, markings on the fins were noted for the northern Tasmanian example of the nominate subspecies; and the types of *C. a. lasti* (which exhibit some variation among themselves) do not differ trenchantly in colour pattern from that specimen.

Together with nominate *Crapatalus arenarius* the present subspecies differs from the New Zealand *C. novaezelandiae* Günther, 1861 in the much larger and less numerous scales.

The subspecific name *lasti* is in honor of Mr Peter R. Last, who collected all the specimens here noted, and who has on various occasions kindly made available material for examination.

Family TRIPTERYGIIDAE

The familial or subfamilial status accorded the threefins in the Australian literature has been an unstable one, shuttling (even in the same author) among Blenniidae, *e.g.*, Macleay (1882), McCulloch and Waite (1916, 1918), Waite (1921, 1923), McCulloch (1922), Lord (1923), Lord and Scott (1924), Whitley (1930, 1948); Blenniidae Clininae, Marshall (1964); Blenniidae Tripterygiontinae (Whitley, 1931); Clinidae, *e.g.* Lord (1927), McCulloch (1929), Whitley (1964a,b); and Tripterygiidae, *e.g.* Munro (1962), Scott (1962), Scott *et al.* (1974). The recognition here of a separate family Tripterygiidae follows that of Greenwood *et al.* (1966).

A single Tasmanian representative, *Tripterygium clarkei* Morton, 1888, appears in the Check-list (McCulloch 1929), there being referred to *Gillias*, Evermann and Marsh, 1900. Only three sets of material appear to have been the subject of primary published notice: (*a*) the type specimen (Morton 1888, pp. xlvii, 78); (*b*) a specimen recorded in R.M. Johnston's memoranda, made available by Whitley (1929, p.65), (*c*) 'some twenty specimens of varying age' captured 'among the piers of Hobart in August 1909'. (Hall 1913, p.82). The relevant accounts are discussed below. It is suggested that (*a*) be relegated to another genus, *Helcogramma* McCulloch and Waite, 1918, and that (*b*) be given a new name; (*c*) appears not now satisfactorily determinable.

A single example of a second species, *Tripterygium macleayanum* Lucas, 1891, relegated in the Check-list to *Gillias*, was reported from this State in Part IV (1939, p.151, fig.2), having previously been known only from Victoria. Some observations on four other individuals, together with remarks on taxonomy, appear below.

Tasmanian examples of a third species, *Brachynectes fasciatus* Scott, 1957, have been noted in Part XV (1967, p.216) and Part XVI (1969, p.175): reasons are here advanced for the retention of *Brachynectes* Scott, 1957, recognised by Whitley (1964) in his Australian name-list, but later rejected by its author (Scott *et al.* 1974, p.286) in favour of *Verconectes* Whitley, 1931. Some observations are made on additional

TABLE 3

Crapatalus arenarius lasti subsp. nov. Dimensions of holotype, (*e*), and four paratypes from Blackmans Bay, southern Tasmania. First line absolute measurements, mm, all other entries permillages of standard length.

Dimension	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)
Standard length	44.0	48.5	53.0	56.0	80.2
Total length	1143	1144	1140	1118	1130
Length to origin of dorsal	341	330	323	323	318
Length to termination of dorsal; ray, membrane	966,998	948,984	951,981	959,982	966,999
Length to origin of anal	287	278	274	277	281
Length to termination of anal; ray, membrane	961,1002	969,996	972,1000	966,986	975,1007
Length to vent (middle)	280	270	266	268	274
Length to pectoral origin; base, median rays	209,273	225,268	208,264	195,225	212,254
Length to ventral origin	159	165	151	179	175
Length of 7th dorsal ray	68	65	74	71	71
Length of 7th anal ray	91	82	85	86	87
Length of pectoral; from base, longest (nth) ray	298,214 (6th)	311,248 (6th)	302,244 (6th)	288,220 (7th)	308,226 (7th)
Length of ventral	136	129	123	126	137
Length of longest (nth) ventral ray	102 (4th)	118 (4th)	114 (4th)	124 (4th)	131 (4th)
Length of ventral spine	57	56	57	63	50
Head	266	262	255	252	237
Snout	55	49	58	52	52
Eye; without, with lid	39,47	39,56	36,47	38,46	35,49
Interorbital	23	21	28	40	37
Anterior internarial; between bases, middles of nares	34,45	29,43	28,43	36,52	27,41
Depth, width at front of eyes	91,116	62,103	57,108	71,121	75,135
Depth, width at back of eyes	111,159	103,165	104,187	98,125	116,173
Depth, width at operculum	141,164	165,223	157,208	125,143	134,203
Depth, width at vent	134,134	155,172	144,173	125,121	150,162
Greatest depth, width of head	134,223	165,206	166,208	125,179	140,223
Greatest depth, width of body	141,138	148,175	151,174	129,125	157,187
Depth, width of caudal peduncle	55,11	63,11	58,9	54,13	54,12

material.

Two new species of *Forsterygion* Whitley and Phillipps, 1939, a genus not previously known in Australia, are described and figured.

A key to the Tripterygiidae recorded from Tasmania is subjoined; this supersedes a key in Part XV (1967, p.216). In accordance with paragraph 23 of the General Recommendations of the Code, it follows the formal descriptions of the new species.

Genus *HELCOGRAMMA* McCulloch and Waite, 1918

Helcogramma McCulloch and Waite, 1918, *Rec. S. Aust. Mus.*, 1, (1), p.58. Type-species, *Helcogramma decurrens* McCulloch and Waite.

Helcogramma clarkei (Morton, 1888)

Tripterygium clarkei Morton, 1888, *Pap. Proc. R. Soc. Tasm.* (1887), p.xlvii, *nom. nud.*, p.78. Type locality: Clarke's [now Clarke] Island, Bass Strait.
Tripterygium clarkei: Johnston, 1891, *Pap. Proc. R. Soc. Tasm.* (1890), p.33 (p. 12 of reprint).
?Tripterygium clarkei: Hall, 1913, *Pap. Proc. R. Soc. Tasm.* (1912), p.82.
Gillias clarkei Lord, 1923, *Pap. Proc. R. Soc. Tasm.* (1922), p.70. *Id.* Lord and Scott, 1924, SYNOP. VERT. ANIM. TASM., pp.13, 82. *Id.* Lord, 1927, *J. Pan-Pac. Res. Inst.*, 2 (4), p.15. *Id.* McCulloch, 1929, *Mem. Aust. Mus.*, 5, (3), p.347 (Morton's specimen). Not *Gillias clarkei* Whitley, 1929, *Pap. Proc. R. Soc. Tasm.* (1928), p.65 (based on *Tripterygium sp.* R.M. Johnston MS = new species, see below).
Tripterygion clarkei: Scott, 1939, *Pap. Proc. R. Soc. Tasm.* (1928), p.150 (Morton's specimen). *Id.* Schultz, 1960, *U.S. Nat. Mus. Bull.*, 202, p.293.
Tripterygion clarkii [*sic*]: Fowler, 1953, *Trans. R. Soc. N.Z.*, 81 (2), p.264. [In the Contents of vol. 81, part 2, p.156 (unnumbered), as the result of a transposition of author names and pagination data, Fowler's paper is attributed to R.K. Dell, and the pagination, 257-267, is given incorrectly as 221-237.]
Norfolkia clarkii [*sic*] Whitley, 1964, *Rec. Aust. Mus.*, 26 (5), p.193 (Morton's specimen).
Norfolkia clarkei Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89 (1), p.54 (Morton's specimen). *Id.* Scott, 1967, *Pap. Proc. R. Soc. Tasm.*, 101, p.216 (not 'R.M. Johnston's specimen', *Tripterygium sp.* = *Gillias clarkei*: Whitley, 1929 = new species, see below).

History and status. Morton referred his single specimen, total length 3 inches [*ca* 75 mm] to *Tripterygion* Risso, 1826 (rendered, as emended by authors, *Tripterygium*), prefacing his account with the generic diagnosis, as given, after Günther, in Macleay's Catalogue (1882, p.26). By Lord (1923, 1927) and by Lord and Scott (1924) it was transferred to *Gillias* Evermann and Marsh, 1900, a course followed in the Check-list (McCulloch 1929). However, *Gillias* has at least part of head scaly, whereas the (short) original description expressly specified 'head scaleless'.

Since the appearance of the texts just cited *Tripterygium clarkei* has been placed in a genus not then established, *Norfolkia* Fowler, 1953. In a key to the Australian species of that genus Whitley (1964a) includes this species; of which he treats *Tripterygium macleayanum*, 1891 as a synonym (however, this identification was shortly after abandoned in the name-list (1964b), in which the species appear separately as No. 1927 and No. 1929). The specification in the diagnosis of Fowler's genus 'Head largely with fine scales and muzzle naked' (type-species, *N. lairdi*, 'Cheek below suborbitals with 6 rows of scales and opercles fully scaled'), while applicable to the Victorian fish described by Lucas is not compatible with the Tasmanian fish described by Morton. In proposing his genus Fowler himself has considered the possibility of relegating to it these two species, together with the third species placed in *Gillias* in the Check-list, *Tripterygion straticeps* Ramsay and Ogilby, 1888 (incorrectly

attributed by Fowler to Ramsay and Macleay). After reviewing accounts of these he observed, 'it appears the generic identity of the three preceding species referred to *Gillias* by McCulloch is questionable. Their inclusion in *Norfolkia* would be equally doubtful till more evidence is forthcoming'. It may be noted in passing that Whitley (1964a) treats *N. lairdi* (a slip in the species reference gives *laird*) as synonymic with *Gillias squamiceps* McCulloch and Waite, 1916 (see comments below, under *Gillias macleayana*).

If the specification by Morton of the lateral line, 'very distinct, terminating in a line with the eighth ray of the third dorsal', is correct and complete, the fish cannot enter *Tripterygion*, but is to be assigned to *Helcogramma* McCulloch & Waite, 1918. Apart from *Lepidoblennius* Steindachner, 1867 (excluded from consideration here by possessing an uninterrupted line extending to caudal base; probably also by having membrane of first dorsal continuous with that of second), this is the only Australian genus diagnosed as having a single lateral line. However, the identification necessarily falls short of being definitive: the lateral line is described in *Helcogramma* as curving down from the shoulder; no indication of its direction in his specimen is given by Morton. It should be noted the concept of *Helcogramma* as formulated by the authors of the genus has undergone revision at the hands of Schultz. In dealing (1960) with material (treated as Clinidae Tripterygiinae) collected in connection with Operation Crossroads 1946 — in line with his earlier revision (1950) in which he recognised five genera only, *Tripterygion, Lepidoblennius, Notoclinus* (referable to Clininae?), *Helcogramma, Forsterygion* — he retains the first of the two criteria of the lateral line on which McCulloch and Waite relied for the separation of *Helcogramma* from *Tripterygion*, 'runs downwards from the shoulder to the middle of the back', but has qualified the second, 'no secondary series of incised scales posteriorly' to admit of a facultative extension beyond the pored (tubuliferous) scales by a collinear series of notched scales (thus providing for the inclusion in *Helcogramma* of several non-Australian species).

Helcogramma clarkei differs from the type-species, *H. decurrens* McCulloch and Waite, 1918 in possessing 16 (*cf.* 13) spines in second dorsal and in having lateral line continued beyond middle of third dorsal (*cf.* end of second dorsal). The New Zealand *Tripterygium medium* Günther, 1861, referred by Whitley (1968, p.80) to *Helcogramma*, has a single lateral line, normally ending beyond second dorsal (Waite (1913) notes in some individuals it continues to base of caudal): it differs trenchantly from *H. clarkei* in having at least 4 (*cf.* 3) spines in first dorsal (quoting Günther's '4-5' Waite (1913, p.7 footnote) observes, 'I have examined a large number of specimens but in none found five spines').

In the course of assessing Morton's account it must be borne in mind that the line of pierced or incised scales constituting in most forms a secondary, posterior lateral line is usually inconspicuous, and if not directly sought for can even be overlooked. With a double lateral line, naked head, second dorsal longer than third (this last feature excluding from consideration *Brachynectes* Scott, 1957 — later abandoned by its author, but maintained in the name-list of Whitley (1964) — also *Notoclinus* Gill, 1893, a representative of which occurs in New Zealand), Morton's fish would be eligible to enter *Tripterygion* Risso, 1826, or, if indeed these be distinct, either of the two remaining genera reported from Australia, namely *Vauclusella* Whitley, 1931 (the initial diagnosis of which has undergone notable modification with the inclusion in it of *V. acanthops* Whitley, 1964) and *Verconectes* Whitley, 1931 (substitute name for *Trianectes* McCulloch and Waite, 1918, regarded as preoccupied by *Trinectes* Rafinesque: this preoccupation has been denied by Schultz (1960, p.283) and by Mees (1962, p.27); it does not appear to exist under the Code). No character reported by Morton for his specimen unequivocally qualifies it for, or debars it from, any one of these.

While a genus with a second lateral line thus remains a residual possibility, it would appear the appropriate course is to accept, in the absence of any evidence

directly negating it, the published description at its face value. Accordingly, it is suggested Morton's fish should be withdrawn from *Tripterygion*, *Gillias* and *Norfolkia* in which it has successively been placed and should be known as *Helcogramma clarkei* (Morton, 1888).

Genus *TRIPTERYGION* Risso, 1826

Tripterygion Risso, 1826, NAT. HIST. EUR. MERID., 3,p.241. Type-species, *Tripterygion nasus* Risso [= *Blennius tripteronotus* Risso, 1810, *fide* Schultz]. Emended by authors to *Tripterygium*.

Enneapterygius Rüppell, 1865, NEUE WIRBELTH. ABYSSIN. FISCHE, p.2. Type-species *Enneapterygius pusillus* Rüppell.

Enneanectes Jordon and Evermann, 1895 *in* : Jordon, *Proc. Calif. Acad. Sci.*, ser. 2, 5, p.501. Type-species, *Enneanectes carminalis* [not of Jordon and Gilbert = *Gillias sexmaculatus* Fowler, 1941, *fide* Schultz].

Trianectes McCulloch and Waite 1918, *Rec. S. Aust. Mus.*, 1 (1), p.53. Type-species *Trianectes bucephalus* McCulloch and Waite.

Notoclinops Whitley, 1930, *Mem. Qld Mus.*, 10, (1), p.20. Type-species, *Tripterygion segmentatum* McCulloch and Phillipps.

Verconectes Whitley, 1931. *Aust. Zool.*, 6 (4), p.324. Type-species, *Trianectes bucephalus* McCulloch and Waite. Substitute name for *Trianectes* McCulloch & Waite, stated to be (but not) preoccupied by *Trinectes* Rafinesque.

Vauclusella Whitley, 1931, *Aust. Zool.*, 6 (4), p.324. Type-species, *Tripterygion annulatum* Ramsay and Ogilby.

Australian genera. Consideration of the current position in respect of the taxonomy of the Australian tripterygiids occasioned by the present observations on several species has shown it to be in considerable disarray. Several locally proposed genera appear, as diagnosed, to be inadequately distinguished from earlier genera established for extralimital forms; furthermore, the status of some species in respect of these, even as constituted, is problematical. The general state of confusion is added to by several other factors, the most important of these being the existence of conflicting views on the true scope of some of the older genera (thus, are species with the first dorsal descendant to be excluded from *Tripterygion* Risso, as maintained by Waite (1913, p.2) against a widely accepted contrary usage?) and the lack in both some generic and some specific descriptions of data on features now recognized as being taxonomically significant (*e.g.*, number of scales between lateral line and base of (second) dorsal, squamation of breast and of pectoral base, nature of pectoral rays).

It has become evident that, pending the completion of a full-scale review of Australian (indeed, Australasian) forms, no comprehensive solution can be looked for. In the circumstances it is concluded the procedure that best serves to eliminate existing anomalies without at the same time bringing about possible fresh confusion is not at this stage to introduce any new proposals, but simply to subsume locally described genera other than *Brachynectes* Scott, 1957 and *Fosterygion* Whitley and Phillipps, 1939 (for these two genera see below) in either *Tripterygion* or *Gillias*, and to refer local species to one of these. The position thus arrived at, as set out in the above table of synonymy, is broadly that adopted by Schultz (1960), differing from it in retaining *Gillias* and *Brachynectes* (latter not noticed by Schultz; overlooked?) as separate entities.

Tripterygion whitleyi sp. nov.

Tripterygium sp. Johnson MS, *in*:Whitley, 1929, *Pap. Proc. R. Soc. Tasm.* (1928), p.65. Type locality: Leven [= Leven River, north-west coast, Tasmania].

? Tripterygium clarkei: Hall, 1913, *Pap. Proc. R. Soc. Tasm.* (1912), p.82. Not *Tripterygium clarkei* Morton, 1888, *Pap. Proc. R. Soc. Tasm.* (1887), p.78 (p.xlvii, *nom. nud.*).

? Tripterygion clarkei: Schultz, 1960, *U.S. Nat. Mus. Bull.*, 202 p.293. Not *Tripterygion clarkii* [*sic*] Fowler, 1953, *Trans. R. Soc. N.Z.* 81 (2), p.264
Gillias clarkei Whitley, 1929, *Pap. Proc. R. Soc. Tasm.* (1928), p.65 (*ex* Johnston MS). *Id.* McCulloch, 1929, *Aust. Mus. Mem.*, 5 (3), p.347, *partim* (Johnston's specimen). Not *Gillias clarkei* Lord, 1923, *Pap. Proc. R. Soc. Tasm.* (1922), p.70; Lord and Scott. 1924, SYNOP. VERT. ANIM. TASM., pp.13, 82; Lord, 1927, *J. Pan-Pac. Res. Inst.* 2 (4), p.15.
Norfolkia clarkii [*sic*] Whitley, 1964, *Rec. Aust. Mus.*, 26 (5), p.193, *partim* (Johnston's specimen).
Norfolkia clarkei Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89 (1), p.54, sp. no. 1927, *partim* (Johnston's specimen).
(Norfolkia sp.) 'R.M. Johnston's specimen' Scott, 1967, *Pap. Proc. R. Soc. Tasm.*, 101, p.216 (in key).

History. The half dozen lines about the holotype of *Tripterygium clarkei* Morton in this Society's *Proceedings* for August 1887 included the comment 'Mr. Johnston had a specimen, but of a different species but had not described it'. In R.M. Johnston's memoranda, redacted by Whitley (1929), an entry headed simply *Tripterygium sp.* probably relates to this individual.

Formally citing references to Morton (1888) and Hall (1913), Whitley treated it as conspecific with Morton's specimen, at the same time transferring it to *Gillias*. It should be noted, however, that if this specimen is that mentioned in the 1887 *Proceedings*, Johnston himself regarded it as a distinct species; it is here so described. While the bestowal of a specific name in the absence of type material is a far from satisfactory proceeding, to be undertaken only after careful consideration, the continued lumping together under a single name of two fish clearly not conspecific is still less satisfactory, constituting a more immediate occasion for confusion.

Description. Johnston's memorandum is here transcribed verbatim. 'Blenny. *Tripterygium sp.* B.4. D.21/8; A.2/19; P.13; V.2. Length scarcely 3 3/5 times length of head, which is nearly equal to height of body. Eye large. Snout 1½ times diameter of eye, surmounted by a long tentacle which has three or four branchlets. A bifurcate tentacle at nostril. Interorbital space less than diameter of eye and 1/3 length of head. Dorsal in three divisions. Black spot on interspace between first two spinous rays. Lateral line conspicuous a [long] curvature of [back], descends at point below termination of first dorsal and follows the line along middle of body with more distant pores. Nasal tentacle bifurcate [see above]. Body reddish brown, mottled with darker; lighter below. Leven'. [*i.e.*, Leven river, north-west coast].

The type-specimen is R.M. Johnston's specimen, the subject of the above description published in the *Papers and Proceedings of the Royal Society of Tasmania*, 1929 (1928) (Whitley *ex* Johnston MS).

The second binomen is in honor of the late Gilbert Percy Whitley, an outstanding figure in the history of Australian Ichthyology, and over many years a valued ever-helpful friend of the writer.

Affinities. Nothing in Johnston's account precludes the referral of his fish to *Tripterygion* in which (as *Tripterygium*) he placed it.

The dorsal count is noted as 21/8, *i.e.*, presumably iii, xviii, 8 (the presence of more than three spines in the first dorsal being highly unlikely). Among published accounts of Australian threefins, that of only one other species, *Vaucluselle acanthops* Whitley, 1964, here referred to *Tripterygion*, has been found in which the number of second dorsal spines is, as here, twice or more the number of dorsal rays, the dorsal formula being iii/xvi to xvii/8 (for available counts in other species enumerated in

the name-list of Whitley the range of the ratio spines/rays is 0.8-1.5, mean 1.22 ± 0.050; the distribution, interestingly enough, being close to symmetrical, with *sk* = − 0.475, and with 11 − expected in normal distribution 12 − items within one standard deviation on either side of the mean). This Queensland species − the brief original description of which (1964), based on the holotype and five paratypes from Heron Island, has since been amplified and complemented by a figure (1965, fig.12) − agrees with the Tasmanian fish in anal count (which is, indeed, much the same in most species), and, as indicated, closely approaches it in dorsal count.

On the basis of the rather few comparable items recorded, *T. whitleyi* differs from *T. acanthops* as follows: P.13 (*cf.* 15-16); depth nearly equal to (0.7) head, or round about 3 3/5ths in 'length' (4.9 in *Ls*, 3.9 in *Lt*); narial tentacle bifurcate (from figure, apparently simple); supraorbital tentacle with three or four branchlets (from figure, probably simple, lanceolate); lateral line ending at termination (from figure, at about three-quarters) of base of second dorsal; first dorsal with black spot between first two spines (no spot); body reddish brown, mottled with darker (as preserved, plain greyish brown, no dark blotches). *T. acanthops* exhibits three exceptional features: unusually elevated second dorsal (longest spine 1.8 longest spine of first dorsal, 1.5 longest dorsal or anal ray); uppermost pectoral ray produced well beyond branched rays, reaching past level of anal base; three conical spines over each eye. It would seem not unlikely that, if exhibited by his specimen, features so visually striking would have engaged Johnston's attention sufficiently to lead him to record one or more of them even in a brief description: the suggestion remains of course purely speculative.

From *T. clarkei* as here accepted (*i.e.*, as represented by Morton's account of his fish) *T. whitleyi* differs trenchantly thus: D.iii, xviii, 8 (*cf.* iii, xvi, 11); lateral line ending 'below termination of first dorsal', *i.e.*, below end of second dorsal, 'first dorsal' being employed by Johnston as equivalent to spinous dorsal, as is evident from his use in the dorsal formula of two counts only, '21/8' (*cf.* below eighth dorsal ray); two lateral lines (if Morton's account correct, one): minor variations included fewer pectoral rays, deeper body, probable difference in nature of narial tentacle. Attention has been called in Part XV (1967, p.216) to the incompatability of the two accounts.

Identity of Hall's material. Hall (1913) provided some observations on the coloration (recognizing 'two types of colour with intermediate stages of variation in each type') of some twenty specimens of a fish he identified as *Tripterygium clarkei* Morton, (noting that the species had hitherto been recorded only from Clarke Island, and that the type was not available for comparison), observing that 'as with the other blennies they were feeding among the mussels of the piles' of piers in Hobart. He stated 'the twenty-four specimens represented in these notes [other species discussed were *Pictiblennius tasmanianus* (Richardson, 1849), *Clinus perspicillatus* Valenciennes, 1836, *Cristiceps australis* Valenciennes, 1836, *Trachinops caudimaculatus* McCoy, 1890] will be additions to the Tasmanian Museum'. In 1938 the then Director of the Museum, Dr J. Pearson, who kindly made a search at the request of the writer, stated the material could not be traced. While there appears every reason to suppose Hall's material did indeed include a tripterygiid, there seems to be no possibility of reaching a conclusion regarding the reliability of his specific determination.

Genus *GILLIAS* Evermann and Marsh, 1900

Gillias Evermann & Marsh, 1900, *Rept U.S. Fish. Comm.*, 1899, p.357. Type-species, *Gillias jordani* Evermann and Marsh.

Gillias macleayana (Lucas, 1891)

Tripterygium macleayanum Lucas, 1891, *Proc. R. Soc. Vict.* (n.s.), 3 (1890), pp. 9, 12,

pl. 3, fig. 4. Type locality: Port Phillip, Victoria.
Gillias macleayanum McCulloch, 1929, *Aust. Mus. Mem.*, 5 (3), p.348.
Gillias macleayana Scott, 1939, *Pap. Proc. R. Soc. Tasm.* (1938), p. 151, fig. 2.
Tripterygium macleayanum: Fowler, 1953, *Trans. R. Soc. N.Z.*, 81 (2), p.264.
Tripterygium macleayanum: Schultz, 1960, *U.S. Nat. Mus. Bull.*, 202, p.193.
Norfolkia clarkei Whitley, 1964, *Rec. Aust. Mus.*, 26 (5), p.193.
Norfolkia macleayana Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89 (1), p.54. *Id.* Scott, 1967, *Pap. Proc. R. Soc. Tasm.*, 101, p.216.

Generic status. As observed in some general remarks on Australian genera above, *Gillias*, sunk by Schultz in *Tripterygion*, is here treated as a valid genus. In terms of this position the present species is excluded from *Tripterygion* by its possession of scales on part of head. There remains the possibility of its belonging to *Norfolkia*, to which it has recently been referred by Whitley (1964a, b) and by the writer (1967).

It agrees with *Gillias* and differs from *Norfolkia* as that genus is understood by its describer in the following points: (*a*) nasal tentacle (none), (*b*) fringed supraorbital tentacle ('No supraorbital flap, though right orbit with free skinny point above posteriorly but none on left orbit'), (*c*) pectoral base and fin naked (base scaled, fin scaled proximally), (*d*) upper and lower sections of lateral line (lower not satisfactorily identified in the writer's 1939 paper, present specification based on new material) separated by one row (two rows) of scales. It differs from *Gillias* (as represented, *fide* Schultz, by its type-species, *G. jordani* Evermann & Marsh) and agrees with *Norfolkia* (*e*) in having upper section of lateral line extending to below third, instead of second, dorsal. In the extent to which the head is scaled it occupies an intermediate position, apparently being somewhat more scaled than in *Gillias*, while noticeably less so than in *Norfolkia*. *Norfolkia* has 'upper edge of supraorbital with a row of very minute and somewhat irregular denticles', while *G. jordani* has 'entire supraorbital edge' (Fowler). In the largest of the specimens specified below about two-thirds of the upper rim of the orbit is abundantly denticulated, in two specimens it bears fewer than half a dozen minute tapering processes, the remaining specimen none; all have some processes fringing hind part of orbit. Similar processes ('fringed papillae', Lucas) occur also in all individuals on the dorsum in about the hinder one-third of the interorbital space.

As interpreted by Whitley, *Norfolkia* comprises four species: *Gillias squamiceps* McCulloch and Waite, 1916*(with which Fowler's type-species, *N. lairdi*, is synonymized — a comparison of the descriptions and figures reveals, however, divergences difficult to reconcile), *N. thomasi* Whitley, 1964, *Tripterygion striaticeps* Ramsay and Ogilby, 1888, *Tripterygium clarkei* Morton, 1888 (with which is synonymized *Tripterygium macleayanum* Lucas, 1891; but note presence in latter, absence in former, of head scales): of these species, the first two have D. iv, the other two D. iii. Inclusion of the additional species in *Norfolkia* entails a not insignificant recasting of the genus (note, *e.g.*, negation of items (*a*), (*b*), in the preceding paragraph; termination of superior lateral line in *N. thomasi* below second dorsal). While there is, indeed, a possibility there could be greater compatability between Lucas' species and a revised diagnosis of *Norfolkia* than between it and *Norfolkia* as established by Fowler, in the absence of any such synoptic redefinition it is expedient to treat the genus as it was originally specified.

New material. As already noted, the only Tasmanian example hitherto reported is that of which a description and figure were given in Part IV (1939) — this account, indeed, appears to be the only non-derivative one to appear since the original description. Four additional specimens: (*a*) *Ls* 24.5, *Lt* 30.0, 37.4, (*b*) 31.0, 37.4, (*c*) 46.0, 55.9, (*d*) 48.6, 61.0, collected by Mr R.H. Green, 2 km north of Greens Beach, north coast, 18 April 1976; Q.V.M. Reg. No. 1976/5/129.

Meristic characters. Br.VI. D. III, XIV, 11; III, XIV, 7; III, XIV, 11; III, XIII, 11.

*Attribution to *Norfolkia* accepted by Hoese, 1976, *Rec. Aust. Mus.* 30 (15), p.427.

A. 20, 20, 20, 21. P. 8 branched + 7 simple (left), 8 + 7 (right); 9 + 7, 9 + 7; 7 + 8; 8 + 7; 8 + 8, 9 + 7. V. 2. C. 12 + 4/3 procurrent rays, 14 + 1/2, 14 + 2/3, 12 + 1/1. L. 1. 28 (scales with tubercles) + 6 (posterior incised scales), 31 + 8, 29 + 6, 28 + 8; the superior element reaching to below penultimate dorsal ray in (*a*), (*b*), (*c*), antepenultimate in (*d*). Sc. tr. at origin of first dorsal 3/1/11-12, at origin of third dorsal 2/1/5.

In (*b*) the third dorsal, with only 7 rays, though intact throughout, is not wholly normal, short segments of several imperfectly formed radial elements being suspended in the membrane. In (*d*) the third spine of the first dorsal is not fully developed.

Comparison with published counts show variations as follows (present data in parentheses): second dorsal XIV (XIII-XIV), third dorsal 10, 12 (11 ; abnormal 7), anal 22 (20-21), pectoral 15, 12 + 6 (7-9 + 7-8), superior lateral line 25-29 (28-31); scales, transverse, at first dorsal origin 3/1/8 (3/1/11-12) at third dorsal origin 2/1/5 (2/1/5). 'Length' 50 mm, standard length 43.8 (24.5-48.6).

Dimensions. A series of dimensions is set out in table 4, the first entry, standard length, being in millimetres, all other entries being permillages of standard length.

Supplement to 1939 account. Lucas' original account is brief and his figure is an outline one only: a detailed account and an illustration were provided for a Tasmanian specimen in Part IV (1929). The present material affords some interesting additional data.

The figure by Lucas shows the lengths of the spines of the first dorsal decreasing; however, the Tasmanian fish is figured with second spine longest, the text giving lengths of 1st, 2nd, 3rd spines as 32, 35, 29% of head length. Three different patterns are found in three of the present specimens (one fish with 3rd spine imperfect), namely 2nd > 1st > 3rd, 3rd > 1st > 2nd, 3rd > 2nd > 3rd. In all other Australian triptery-giids hitherto described the series is reported either as regularly ascendant or as regularly descendant (slope treated as a generic character by Waite); contrast, however, descriptions below of two species of *Forsterygion*. In the present species the variation is perhaps rendered somewhat less significant by the subequal size of the spines.

Maxilla to below hinder one-third of eye (1939 specimen and Lucas' figure); here to 0.5, 0.5, 0.7, 1.1 eye.

Lucas neither mentions nor figures a second lateral line, and in the 1939 account no such line was clearly recognized, 'a slight mediolateral groove, apparently without perforations, extends forward from caudal base to level of about eighth ray of third dorsal'. A similar groove occurs here (traceable in some individuals further forward), with in it a line of 6-8 notched scales continued cephalad maximally to below middle of rayed dorsal, there separated from superior lateral line by one scale-row.

Jaws equal anteriorly in (*b*), (*c*), lower projecting somewhat in (*a*), (*d*). Pectoral to level of 12th spine of second dorsal in (*b*), (*c*), (*d*), 1st dorsal ray in (*a*); ventral to vent in (*a*), (*d*), just short of it in (*b*), (*c*). Anal papilla bulbous or semiconical, longitudinally plicate, the rounded posterior end with a central aperture ringed by the six or eight mounded ends of the plicae. Angle of operculum notched between two variously developed horns, lower subcontinuous with tip of branchiostegal membrane.

Scales on head small, ctenoid, somewhat more extensive than previously reported, covering preoperculum down to level of lower border of orbit, and on operculum extending across anterior 0.7-0.9 of width in upper half, the posterior bounding arc curving

forward and down to meet preopercular margin well below level of inferior orbital border. Scales on occiput reaching to just behind back, or barely beyond front, of base of supraorbital tentacle. Arising shortly above upper end of preoperculum on each side and running transversely a slightly sinuous, overall proconvex line of about 30 small mounded elevations, basally contiguous, each surmounted by a digitiform process, length of whole structure exceeding half length of head, its distance behind level of eye 3-5 times its distance from dorsal origin. This feature, not previously reported, is perhaps comparable with 'a well-defined series of upraised pores separating the head from the back' found by McCulloch and Waite (1918, p.54) in their *Trianectes bucephalus* from South Australia: its morphological relations are identical with, and it may represent a less developed equivalent of, the curious conspicuous transverse series of cirri found in two genera of Blenniidae Salariinae, *Cirripectes* — represented in Australia by the Queensland *C. filamentosus* (Alleyne and Macleay) — and *Exallias;* it may be speculated that these linear structures are prefigured by the paired nuchal tentacles found in other salariinids, *e.g.*, some species of *Salarias*.

Coloration. In general much as already described (1939, p.154). Chief features worthy of notice: general colour, after short preservation in alcohol, greenish somewhat greyish, subsequently mainly yellowish, fawn or brownish (1939 yellowish grey, in formalin); dark bars on trunk and tail less sharply demarcated laterally, least distinct in (*a*), generally not reaching ventral profile; whole preanal ventral surface of trunk bright orange (anterior half flesh-coloured); large rounded carmine spot on occiput, subsequently barely observable; conspicuous light and dark genal markings disposed as before, but showing variation in relative width; caudal (noted in 1939 as lacking discrete markings, and so in (*d*)) in general conspicuously patterned with 12-15 well defined dark cross bars; in all except (*d*) anal strongly banded, 3 dark bars on each ray; less well developed banding on second and third dorsals, former without any definite dark distal line; first dorsal rays dark.

Genus *FORSTERYGION* Whitley and Phillipps, 1939

Forsterygion Whitley and Phillipps, 1939, *Trans. R. Soc. N.Z.*, 69 (2), p.236.
Type-species, *Blennius varius* Bloch and Schneider, 1801 (= *Tripterygion nigripenne* Valenciennes, 1836. ? = *Tripterygion capito* Jenyns, 1842).

Forsterygion multiradiatum sp. nov.

(fig. 2)

Type-specimens. Holotype, Kangaroo Bay, Bellerive, south-eastern Tasmania, standard length 105 mm, total length (caudal slightly imperfect distally) 120+, taken in fish trap ; 2 fm (3.7 m), 12 August 1975, collector Mr P.R. Last, Queen Victoria Museum, Launceston Reg. No. 1976/5/202, Q.V.M. Type No. 230. One paratype, Bellerive, south-eastern Tasmania, standard length 92, total length 108, August, 1976, collector Mr T. Walker, Q.V.M. Reg. No. 1976/5/203, Q.V.M. Type no. 231: taken with type-specimens of next species. Though its caudal fin is somewhat frayed distally, the larger specimen is otherwise more satisfactorily preserved; furthermore the smaller specimen possesses an anomalous pectoral fin, with one ray more then the left side than on the right.

Meristic characters. Where there is a difference between the holotype and the paratype the specification for the former is here, and throughout the description, cited first. B. 6 D. vii, xxiv, 14; vii, xxiv, 15. A. ii, 29. P. 19 (3 + 9 + 7); left fin 20 (3 + 8 + 9), right 19 (3 + 8 + 8). V.2. C.15, of which 10 (9) are branched. L. lat. tubules 36 left, 35 right; 33 left, 35 right; ending below 3rd, 5th (4th) dorsal ray + pored scales 15 left, 17 right; 19 left, *ca* 16 right. Sc. *ca* 67, *ca* 69. Sc. tr. at second dorsal origin 6 + 1 + 21, on caudal peduncle 2 + 1 + 3. Scales between upper lateral line and dorsal profile at second dorsal origin 7; between upper and lower lateral lines 2.

TABLE 4

Gillias macleayana (Lucas, 1891). Dimensions of 4 examples from 2 km north of Greens Beach, north coast, Tasmania. First line absolute measurements, mm, other lines relative magnitudes, permillages of standard length.

Feature	(*a*)	(*b*)	(*c*)	(*d*)
Standard length	24.5	31.0	46.0	48.6
Total length	1224	1206	1215	1225
Length to origin, termination of first dorsal	245, 302	216,277	217,260	220,265
Length to origin, termination of second dorsal	367,702	339,710	322,637	329,681
Length to origin, termination of third dorsal	735,898	716,936	680,870	712,910
Length to origin, termination of anal	453,898	440,936	478,883	473,922
Length to pectoral, to base, origin of middle ray	241,302	213,287	252,283	247,323
Length of pectoral, from base, origin of middle rays	420,339	400,303	410,309	409,331
Length to ventral	176	177	174	191
Length of ventral, inner ray, outer ray	241,171	206,145	228,174	239,185
Length to vent	429	419	457	449
Head	282	290	319	315
Snout	53	65	67	70
Eye, with rim, without rim	104,86	97,87	91,65	87,73
Interorbital	41	39	30	33
Depth, width at front of eyes	104,94	123,113	104,107	97,121
Depth, width at back of eyes	180,131	161,135	152,152	166,165
Depth, width at opercular border	192,200	190,187	189,174	202,206
Depth, width at vent	200,114	178,103	174,130	189,132
Depth, width, greatest	204,206	194,226	191,215	202,212
Depth, width, of caudal peduncle, least	86,21	97,23	85,17	81,19
First dorsal spines, length of first, last, longest	102,108,98	100,97,106	85,91,98	80,107,-
Second dorsal spines, length of first, last, longest	118,73,161	98,65,129	-,63,111	107,47,150
Third dorsal rays, length of first, last, longest	102,78,196	129,95,174	-,87,176,	123,68,144
Anal rays, length of first, last, longest	69,78,153	66,74,135	65,88,152.	43,82,154

Dimensions. A series of dimensions, expressed as permillages of standard length, is included in table 5, which gives also dimensions of a second species described below.

General description. Length of head 3.62, 3.47, greatest depth of head 4.77, 4.84, greatest depth of body 5.25, 4.38 in *Ls*. Depth of caudal peduncle 3.30, 3.34 in head. Eye 4.14, 3.90, snout 3.97, 3.79 in head. Interorbital 2.0, 1.9 in eye. Length to vent 1.55, 1.50 head, 2.33, 2.31 in *Ls*.

Body moderately elongated, compressed, tapering evenly from head to caudal peduncle. Head rather large, pointed anteriorly, subcylindrical posteriorly. Snout broad, blunt, slightly depressed. Eye large, elevated, not quite entering profile. Orbit smooth, not in general noticeably raised above eye, but forming a low keel between 1 and 4 o'clock (left side viewed), continued as a fine ridge to just beyond bottom of eye. Interorbital with on either side a low longitudinal tumescence, flanking a pronounced median trough with sloping sides. Mouth oblique, upper jaw barely

in advance of lower; lips tumid; maxilla extending back to between anterior and posterior nostrils, expanded posteriorly, most backward point near top of hind border, greatest oblique width subequal to direct distance from eye. A well developed palatal frenum. Anterior nostril equidistant (dividers) from border of preorbital and orbit; a low mounded fleshy base from which arises a cone, partly gelatinous in appearance, truncated obliquely forwards and outwards, surmounted on its hinder rim by a briefly stalked broad ovoid hyaline lamella fringed with 6-8 tapering processes. Posterior nostril a subcircular (subelliptical) opening with a slightly raised minutely fimbriated rim; slightly externad of anterior nostril, about its own diameter from orbit at 10 o'clock. A broad supraorbital tentacle, with very brief base and 4-5 long slender processes; set right on orbit at 1 o'clock (left side viewed), about equal in height to nasal tentacle. Gill membrane free from isthmus, broadly united across it; median point of posterior border an eye diameter in advance of pelvic insertion; branchiostegals 6, 6th (lowest) and 5th not closer together than 5th and 4th.

Teeth in the jaws cardiform, in a broad band narrowing rapidly posteriorly; a distinct outer row, teeth minute erect behind, progressively increasing in size and becoming recurved in front; better developed in upper jaw, where there are about 25 on each side. A rather large narrow arc of minute teeth on the vomer, subcontinuous with minute palatine teeth in two or more rows anteriorly becoming uniserial behind.

One small naked area immediately behind, extending somewhat below, hind half of pectoral base; one on ventral surface behind, contiguous with, bases of ventral rays, its width about one-third of whole body width here, its fore and aft extension a little less. Otherwise whole body with rather large scales forward on dorsal and upper lateral surfaces to a line from origin of first dorsal to upper end of branchiostegal membrane or insertion of uppermost pectoral ray, the line of cessation sharp: on lower lateral and ventral surfaces in advance of a line from near pectoral base to vent scales suddenly become small, and continue to decrease in size forward, finally being minute and at the same time become less apparent, more deeply embedded. General body scales rather large, strongly ctenoid, with modally about 30 stout straight acute spinules, traceable far back from scale margin; small scales on lower part of abdomen cycloid. The pectoral base is smooth and has the appearance of being naked; it bears, however, minute cycloid scales. Head wholly naked. An area bounded behind by the sharply delimited anterior border of the body scalation, laterally by a line back from middle of orbit about to level of dorsal origin, above by a line just behind middle of interorbital thickly set with minute elevations tending to be arranged in short transverse series. Rest of head smooth, except for numerous small pores with slightly (barely) elevated rims. These include many irregularly scattered around lower half of orbit and extending upwards and forwards on to the preorbital; about two score near margin of preoperculum; 8-10 on each mandibular ramus; a number on dorsum between nostrils and extending back on to front of interorbital. Upper lateral line following very closely dorsal profile, distance from it at level of vent two-fifths that from ventral profile; 35, 36 (33-35) contiguous elongate tubules, extending to below 3rd, 5th (4th) dorsal ray. Lower lateral line of minutely pored scales traceable with difficulty, total probably 19, just overlapped by upper line.

First dorsal with 7 weak spines, originating above upper angle of operculum; base 3.7 (3.7) in head; spines increasing in length back to penultimate, which is 1.8 (1.8) first, or 3.7 (3.8) in head; last 1.2 (1.2) first; just connected to base of second dorsal by a small forward triangular extension of membrane of latter. Second dorsal with 24 tolerably rigid spines; base 7.9 (7.2) base of first dorsal, 2.4 (1.9) base of third; first spine 1.6 (1.6) in longest (12th, 10th), which is 2.6 (2.8) last, or 2.1 (2.1) in head; connected to third dorsal by low membrane about half height of last spine. The border of the second dorsal is in marked contrast to that of the next species (which attains its greatest height anteriorly and runs backward and downward almost linearly), presenting a moderately convex curve rising evenly to shortly before middle, then dropping somewhat more rapidly but still evenly. A more precise

specification of the curve is the following. Where L = length of spine, N = serial number of spine counted caudad, N^1 = serial number counted cephalad, $L = bN^k$ for spines {1-10} $L = bN^{1(k)}$ for spines {11-24}; the best straight lines for the holotype, expressed in the convenient form of $\log L = k \log N[N^1] + b$, being $\log L = 0.2237 \log N + 0.9384$ ($t = 26.902$***) and $\log L = 0.3609 \log N^1 + 0.7373$ ($t = 72.067$***). Measured (in parentheses, predicted) spine lengths (holotype) are: {1-10} 8.7 (8.7) , 10.0 (10.1), 11.0 (11.1), 11.7 (11.8), 12.8 (12.4), 13.2 (13.0), 13.7 (13.4), 13.9 (13.9), 14.0 (14.2), 14.1 (14.5); {11-24} 13.9 (14.2), 13.7 (13.8), 13.4 (13.4), 12.9 (13.0), 12.6 (12.5), 12.2 (12.1), 11.8 (11.6), 11.0 (11.0), 10.6 (10.4), 9.9 (9.8), 8.9 (9.0), 7.9 (8.1), 7.0 (7.0), 5.5 (5.5), Third dorsal with 14 (15) simple rays: border convex, rising steeply to 3rd ray, which is 1.1 (1.2) first, 2.6 (2.6) last, 2.2 (2.0) in head; no connexion by membrane with caudal peduncle. Anal with 2 spines, first minute about one-fourth second, which is less than half first ray; 29 simple rays, soon attaining modal height, increasing somewhat posteriorly; longest (about 22nd) ray 1.8 (1.7) first, 2.0 (1.8) last, 2.4 (2.5) in head; membrane excavate for up to one-third length of ray; originating below 10th (10th) spine of second dorsal, base 1.1 (1.2) second dorsal base, 2.1 (2.0) in *Ls*; no membranous connexion with peduncle; laid back, reaches nearly to (to) insertion of lowest caudal ray. Pectoral rather large, broadly rounded, reaching when adpressed to below 16th (16th) spine of second dorsal; 19, 19 (19 right, 20 left) rays, comprising, from above 3,3 (3,3) simple, pointed; 9,9 (8,8) branched; 7,7 (8 right, 9 left) unbranched, bluntly pointed, somewhat recurved distally; first 5.9 (6.6), last 2.6 (2.6), longest 1.2 (1.2) in head. Pelvic with 2 simple tapering rays, connected by membrane for about half length of outer, which is 1.4 (1.1) in the inner, the latter 1.4 (1.6) in head. Caudal with 15 rays, 10 (9) branched, fin abraded posteriorly in holotype; in paratype truncate, its length 1.7 in head.

Coloration. *(i). Holotype.* Ground colour of dorsal surface and lateral surface down to midlateral line dark brown, deepening a little anteriorly; below dorsal profile a line of somewhat lighter areas, not very conspicuous, largest, six or eight times smallest, about two-thirds eye diameter, 5-6 below second dorsal, 3 below third; a small pale spot at upper, another at lower, termination of caudal peduncle. Ventral surface very pale brownish, in parts somewhat greyish. Small naked patch behind pectoral deep cream, naked patch behind pelvics very pale orange. Dorsum of head and lateral surface about down to level of lower border of orbit more or less concolorous with trunk. Cheek and opercle brownish olivaceous; branchiostegal membrane, inflated, somewhat lighter. Ventral surface greyish, lower lip darker. Nasal tentacle hyaline, in parts dusky. Ocular tentacle dark brown proximally, the processes mostly greyish.

First dorsal chiefly dark brown, a few small irregular areas lighter. Second dorsal virtually uniform medium brown, the rays lighter; tips of rays conspicuously whitish. Third dorsal much like second, a trifle lighter; extreme tips of some rays greyish. Anal with ground colour similar to that of second dorsal; all or most of the distal one-third or so of the ray projecting beyond membrane, together with a small slip of the well excavated membrane at its outer attachment to the hind border of the end of the ray, conspicuously white or slightly bluish-white. Pectoral membrane pale greyish or hyaline; rays of lower half brownish, a distinct bronze tinge along their interior surface; rays of upper half noticeably lighter; anterior surface of base yellowish grey, covered abundantly with minute red-brown chromatophores; posterior surface deep cream, nitidous, a sprinkling of dark chromatophores near upper border. Pelvic rays dusky greenish proximally, lighter distally; membrane greyish, microscopically punctulated with red-brown. Caudal concolorous with rayed dorsal.

(ii) Paratype. In general much like holotype. Chief differences: darker overall in body and all fins, the first and second dorsals and several lower rays of the pectoral approaching black; mottling on lower half of lateral surface of trunk and tail with darker component less extensive, the brown spotting confined to half or less than half, instead of covering all or most, of the scale; light areas below dorsal profile discernible in hinder half only and there quite obscure.

Discussion. *(i). Generic status.* In proposing *Forsterygion* Whitley and Phillipps nominated a type-species, *Blennius varius* Bloch and Schneider, 1801, *ex* Forster MS (noting its identity with *Tripterygion nigripenne* Valenciennes, 1836), but gave no formal generic diagnosis. Schultz (1960, p. 282) in a key characterizes the genus thus. 'First dorsal fin with V to VII spines, second with about XIX to XXII spines; anal with about II, 25 to 27; pectoral rays about 17 to 19; vertical [subvertical] scale rows about 60 to 65; lateral line, anteriorly, separated from base of second spiny dorsal by 5 or 6 scales; breast scaly; head naked'. From the type-species, *F. varium*, as described and figured by Waite (1913, p. 7, pl. III), this differs notably in specifying 'breast scaly' (Waite 'throat and chest naked') — but see observations above on the inconspicuous nature of the scales in these regions and diversity in the two species here described — and in extending first dorsal, second dorsal, anal and pectoral counts.

The present species fails to meet the criteria set out by Schultz as follows: 2 more second dorsal spines, 2 more anal rays, one more pectoral ray (in one fin of paratype), a few more scales in the lateral series. On comparison with the type-species perhaps the most striking discrepancy is that presented by the profile of the first dorsal fin, which in *F. varium* rises regularly to the last spine (5th or 6th ; figured by Forster, 6th; by Waite, 5th), whereas here it rises only to the penultimate (6th) and then falls — a pattern in which any spine of the first dorsal other than the first or last stands highest being highly unusual among tripterygiids generally (*cf.*, however, observations above on Tasmanian examples of *Gillias macleayana* and on species described below). Despite these features, to which absolute value could be granted only by the establishment of a new genus, the general agreement in other characters with *Forsterygion* as conventionally accepted appears of sufficient weight to lead to the attribution of the present species to that genus.

(ii). Species affinities. No member of this genus has hitherto been reported from Australia. From what is probably its nearest ally the New Zealand *F. varium*, as that species is described in Waite's revision (1913), the present fish is immediately separable by, among others, the following features: D. vii, xxiv, 14-15 (*cf.* v-vi, xx, 12); nature of first dorsal profile; A. ii, 29 (*cf.* 25). From the second Tasmanian species described below (with the type-specimens of which paratype of the present species was taken) it differs chiefly thus: 4 more spines in second dorsal; profile of that fin well curved, highest towards middle (nearly straight, highest anteriorly), fin bordered (not) with white; total anal radial elements 31 (24-25); no naked strip flanking first dorsal base; upper (lower) portion of posterior border of maxilla reaching farther back; no noticeable light or dark markings on lower part of flank.

As the data in table 5 show, there is marked overall morphometric similarity between the two Tasmanian species of *Forsterygion*. However, in 5 relative (*TLs*) dimensions the mean value for the present is statistically significantly less than that for the other species; mean length to vent 431.0, 462.5, t = 2.681*; length to third dorsal termination 922.0, 969.5, t = 3.272*; length to anal origin 450.0, 484.0, t = 2.764*; length to anal termination 938, 973.8, t = 3.245*; depth of caudal peduncle, 84.0, 95.2 t 3.437*. In view of the absence of any real information on differential growth of these features the significance of these differences remains uncertain. However, it may be noted that in the two cases in which there appears to be some tendency for the ratio to vary with overall size (length to termination of dorsal, to termination of anal) the values for the smaller specimens of the other species are suggestive of a possible positive correlation of ratio with *Ls*, whereas the mean value for the larger fish of the present species is less than that for the smaller fish.

The specific name *multiradiatum* is from *multi*, a combining form of *multus*, many, plus *radiatum*, from *radiatus*, the past participle of *radiare*, to furnish with spokes or rays, from *radiatus*, a ray, signifies many-rayed, the allusion being to the large number of dorsal and anal radial elements, the counts exceeding those of the type-

species and also the upper extremes of the range attributed by Schultz (1960) to *Forsterygion*.

FIG. 2. - *Forsterygion multiradiatum sp. nov.* Holotype, standard length 105 mm, total length (caudal slightly imperfect distally) 120 mm, Kangaroo Bay, Bellerive, south-eastern Tasmania; Queen Victoria Museum Reg. No. 1976/5/202, Type No. 230: x 1.

FIG. 3. - *Forsterygion gymnotum sp. nov.* Holotype, standard length 64.5 mm, total length 76.7 mm, Montagu Bay, south-eastern Tasmania; Queen Victoria Museum Reg. No. 1976/5/204, Type No. 232: x 1½.

Forsterygion gymnotum sp. nov.

(fig. 3)

Type-specimens. Holotype, Montague Bay, south-eastern Tasmania, August 1976, standard length 64.5 mm, total length 76.7, collector Mr T. Walker, Queen Victoria Museum, Launceston Reg. No. 1976/5/204, Q.V.M. Type No. 232. Five paratypes, same history as holotype, (*a*) *Ls* 54.1, *Lt* 65.1, (*b*) 55.0, 66.5, (*c*) 62.4, 73.5, (*d*) 64.0, 76.9, (*e*) 67.0, 79.4. One paratype will be offered to each of the following institutions, British Museum of Natural History, London, Australian Museum, Sydney, Tasmanian Museum, Hobart, the remaining two being deposited in the Queen Victoria Museum, Launceston, Reg. Nos. 1976/5/205,206, Q.V.M. Type Nos. 233,234. Taken with paratype of *Forsterygion multiradiatum*.

Meristic characters. Where different values are found in holotype and paratypes the

value for the holotype is here followed, after a semicolon, by the range (in parentheses, mode) of the paratypes. B. 6. D. vii, xx, 14; 13-14 (14). A. i, 24; 23-24 (23). P. 17, 2 + 7 + 8; 17, 2-3 (3) + 5-7 (7) + 8-9 (8). V. 2. C.16, 9 being branched; 15-16 (15), branched 9-10(10). L. lat. tubules left 26, right 25; 22-25 (22); ending below 17th dorsal spine; 17-18th (17th): + pored scales left 15, right 22; *ca* 15-*ca* 28. Sc. *ca* 70; *ca* 66-*ca* 72. Sc. tr. at second dorsal origin 5 + 1 + *ca* 23, on caudal peduncle 3 + 1 + 3. Scales between upper lateral line and dorsal profile at origin of second dorsal 5, at middle of fin base 7; between upper and lower lateral lines 2.

Dimensions. A series of dimensions, with standard length, total length in mm, all other measurements expressed as permillages of standard length, is included in table 5, which also gives corresponding dimensions of the two specimens of the species described above.

General description. From here onwards data for paratypes are given in parentheses. Length of head 3.73 (3.24-3.72, $\bar{x}$ 3.51 ± 0.0579); greatest depth of head 4.92 (4.51-5.00, $\bar{x}$ 4.74 ± 0.0598); greatest depth of body 4.51 (4.23-4.54, $\bar{x}$ 4.46 ± 0.0366) in *Ls*. Depth of caudal peduncle 2.93 (2.70-3.40, $\bar{x}$ 2.99 ± 0.734) in head. Eye 3.84 (3.43-4.05, $\bar{x}$ 3.80 ± 0.0696); snout 3.46 (3.60-4.25, $\bar{x}$ 3.84 ± 0.0882) in head. Length to vent 1.66 (1.55-1.75, $\bar{x}$ 1.63 ± 0.0237) in head, 2.25 (2.07-2.2, $\bar{x}$ 2.15 ± 0.0181) in *Ls*.

It is found that, with means for the six specimens used, tail, trunk head are of such relative anteroposterior extension that the lengths to their posterior boundaries are an exponential function of the first three natural numbers, these lengths thus being collinear and falling on integral values in a log-log plot. With L = length, mm, to hind border of region (tail, trunk, head) and N = 1, 2, 3 the equation is $L = 6.2040\ N^{-1.1567}$; t (d.f.1) = 42.661***; actual (computed) values 61.7 (62.0), 28.3 (27.8), 17.2 (17.7).

General form, features of head, including dentition, similar to those of species described above. Chief differences: eye reaching dorsal profile; orbital keel barely developed; maxilla somewhat less expanded posteriorly, reaching back to eye (*cf.* between posterior nostril and eye), its most backward extension near bottom (top) of its hind border; median point of posterior border of branchiostegal membrane about half (one-tenth to three-fifths) eye diameter in advance of ventral insertion.

Strongly ctenoid scales, similar to those of *F. multiradiatum*, cover whole tail and most of trunk. Along an arc from about middle of pectoral base to near vent they suddenly decrease in size by a factor of the order of 10, and become cycloid: in advance of this line the lower lateral and ventral surfaces present every appearance of being naked. Pectoral base smooth on both surfaces; no scales obtained on manoeuvring with a needle. No predorsal scales on dorsum; the naked area extending back on either side of first dorsal, about one (down to little more than half) eye diameter wide, continuing, rapidly narrowing, beside first four or five spines of second dorsal; immediately adjacent scales very small. Head wholly naked. Upper lateral line similar in structure and course to that of *F. multiradiatum*, but having fewer tubules, 25, 26, (22, 25), *cf.* 33-36, and ending earlier, shortly before end of second dorsal. Full course of lower lateral line of pored scales traceable with difficulty; total number probably 28.

First dorsal with 7 spines (rather more rigid than those of earlier species), originating above upper angle of preoperculum, just connected to second dorsal, its distal border virtually linear, almost parallel to its base, hence sloping somewhat upward and backward relative to general anteroposterior axis of fish (in one paratype, (*d*), profile virtually horizontal); first spine 3.5 (3.0-3.9, $\bar{x}$ 3.5), middle 3.4 (2.6-4.0, $\bar{x}$ 3.3), last 5.2 (3.0-5.5, $\bar{x}$ 4.5) in head; base 2.4 (2.3-2.4 $\bar{x}$ 2.34 ± 0.0246) in head. Second dorsal with 20 spines; border almost linear, sloping down and back; first spine 1.97 (1.7-2.1, $\bar{x}$ 1.91), second, longest (usually longest), 1.92 (1.8-2.2 $\bar{x}$ 1.94), middle 2.08 (1.7-2.4, $\bar{x}$ 2.19), last 4.68 (4.4-5.0, $\bar{x}$ 4.59) in head; base

relative to base of first dorsal tolerably constant, 3.3 (2.9-3.5, $\bar{x}$ 3.15 ± 0.0101); however, relative to base of third dorsal quite variable, 1.3 (1.4-1.9, $\bar{x}$ 1.64 ± 0.0916), there being significant negative correlation of the ratio with standard length (for all 6 specimens, $r = -0.875$ ($z = 1.364$), $t = 3.610$*); connected by membrane to very base of first dorsal ray. Third dorsal with 14 (one paratype 13) simple rays, border rising to second or third ray, thereafter almost linear, sloping down and back, very nearly parallel with second dorsal border; first ray 1.9 (1.8-2.4, $\bar{x}$ 2.13), second 1.7(1.7, -2.3, $\bar{x}$ 1.97), third 1.7 (1.6-2.0, $\bar{x}$ 1.83), middle 2.2 (2.0-2.7, $\bar{x}$ 2.29),last 3.5 (3.5-5.2, $\bar{x}$ 4.46) in head. Anal originating below 10th spine of second dorsal; one short spine, largely embedded (embedded, free) and 24 (23-24) stout simple rays, tips obtuse, usually more or less uncinate; membrane excavate for about one-third or less (about one-fifth to about one-third) of ray length; largely equal in height after first few rays, but rising somewhat towards termination; longest ray, about 20th, 1.3 (1.2-1.4, $\bar{x}$ 1.23) first,1.6 (1.4-1.7, $\bar{x}$ 1.55) last,or 2.3 (2.5-2.8, $\bar{x}$ 2.63) in head; base 1.50 (1.20-1.38, $\bar{x}$ 1.26) second dorsal base, 2.02 (1.95-2.52, $\bar{x}$ 2.16) in *Ls*; no membranous attachment to caudal peduncle. Pectoral rather large, broadly rounded, extending to below 12th (10th-14th) spine of second dorsal, with 17 (17) rays, comprising, from above, 2 right 2 left simple, unbranched, pointed, 7, 7 branched, 8, 8 unbranched, more or less uncinate(2 + 7 + 8 (5 fins), 3 + 6 + 8 (3), 2 + 6 + 9 (1), 3 + 5 + 9 (1)); first (uppermost) 4.4 (3.5-6.0, $\bar{x}$ 4.27), last 3.8 (2.5-3.5, $\bar{x}$ 2.87), longest, 10th (9th-11th, modally 10th), 1.0 (1.0-1.1, $\bar{x}$ 1.07) in head. Ventral with 2 simple rays, connected by membrane for 0.6 (0.5-0.6, $\bar{x}$ 0.58) length of inner ray, which is 1.2 (1.3 -1.4, $\bar{x}$ 1.32) outer, which is 1.5 (1.4-1.6, $\bar{x}$ 1.52) in head. The relative size of the ventral-anal interval, differences in which in a species of *Helcogramma* have been noted (Schultz 1960, p. 300) as representing sexual dimorphism, is here a function of size of fish, the interval, as *TLs*, exhibiting negative correlation with *Ls*, $r = -0.960$ ($z = 1.949$), $t = 6.855$**. Caudal rounded; 16 (15-16) rays, 9 (9-10) branched; length 1.4 (1.3-1.5, $\bar{x}$ 1.42) in head.

Coloration. *(i). Holotype.* General colour of lateral surfaces of trunk and tail medium brown, a little lighter in lower half; about 10 subelliptical (major axis vertical) or subcircular greyish patches (differing somewhat on the two sides) in a line from shortly behind pectoral base to near caudal base, decreasing in size backward, largest a little smaller than eye; on caudal peduncle light colour extending diffusely beyond these patches, which thus become less definite, so that region may be described indifferently as dark mottled with lighter or vice versa; further irregular, mainly longitudinal lighter areas adjacent to much of dorsal profile. Ventral surface more or less concolorous with lower lateral surface, rather lighter in advance of vent. Head in general not noticeably different from trunk, a little more greyish on branchiostegal membrane; ventral surface dark greyish with some dusky touches; lips concolorous with one another and with upper surface of snout. Nasal tentacle hyaline and greyish; supraorbital tentacle grey, briefly darker proximally. First dorsal very dark brown, almost black. Second dorsal much like first anteriorly, a little lighter posteriorly; no white tips to rays. Anal in general about concolorous with second dorsal, but distal one-third or so of rays conspicuously lighter, lacteous. Pectoral membrane greyish, rays medium brown (those of lower half slightly darker), with tinges of bronze; front surface of base concolorous with trunk, back surface pale, glistening. Ventral evenly dark brown approaching black. Caudal overall about concolorous with rayed dorsal; some scattered minute dark chromatophores.

(ii). Paratypes. Ground color much as in holotype, darker in one, somewhat lighter in two, the latter with some hints of greenish below lateral line. Whereas in (*b*) and (*c*), as in the holotype, the general impression produced by the midlateral pattern is that of a row of more or less round light markings separated by darker bars, in (*a*), (*d*) the darker areas are more rounded, the net effect here being rather the reverse one of a row of dark spots (up to a dozen) on a light background; markings scarcely developed in (*e*). Irregular lighter areas generally developed, often obscurely, along bases of dorsal fins, but in smallest individual, (*a*), the general

effect is that of half a dozen dark patches here. Head in general much as in holotype; decidedly lighter in (*a*), which is lightest overall. Lips generally concolorous with each other and, or but slightly lighter than, dorsum of snout. Supraorbital tentacle greyish, brownish; may be tinged with greenish. Vertical fins in general much as in holotype, sometimes a little darker or lighter, but maintaining the same relative intensity *inter se*. In (*a*), in which rayed dorsal is lightest, a brief encroachment on fin membrane of two dark spots near dorsal profile; in (*b*) similar dark patches on fin but no spots on body. Lower half (or less) of pectoral regularly darker than rest. Ventrals either totally dark, approaching black, or with very slight lightening near tip (never conspicuously bicolor as in *F. multiradiatum*).

Discussion. *(i). Generic status.* See remarks on *F. multiradiatum* above. Whereas that species is in agreement with *Forsterygion* as recognized by Schultz in having the ventral surface between the vent and the ventral fins scaled (though very obscurely), in the present species this area is apparently naked, thus being compatible with the account by Waite of the type-species. Our fish seems clearly referable to Whitley and Phillipps' genus.

(ii). Species affinities. *Forsterygion gymnotum* is immediately distinguishable from all described Australasian tripterygiids other than *F. multiradiatum* by the 7 spines of the dorsal; and from that species by the subhorizonal distal border of that fin; other differences between the two Tasmanian species are noted above and in the subjoined key. From the type-species, the New Zealand *F. varium* — the meristic characters of which as reported by Waite (1913) have been extended by McCulloch & Phillipps (1923, p.21) — it differs trechantly in the two features of the first dorsal, and is further separable on a number of minor characters, *e.g.*, interorbital excavate (*cf.* flat), mouth short of (to middle of) eye, ocular tentacle multifid (bifid), nasal tentacle multified (simple), shape of head, coloration. Among New Zealand tripterygiids its nearest cogener is *F. robustum* Clarke, 1879 — if that species is distinct; synonymized by Waite (1913) with *F. varium* (Forster, 1801) — but it appears clearly to be distinct from all New Zealand forms. However, the taxonomic position in respect of the New Zealand fauna is at present a greatly confused one; a revision by Mr J.Moreland, National Museum of New Zealand, is currently in course of preparation.

The specific name *gymnotum* is from the Greek γυμνός, naked, plus νῶτον, back, in allusion to the present of a naked, non-scaled area on the back on either side of the base of the first dorsal fin and the early part of the second dorsal.

Genus *BRACHYNECTES* Scott, 1957

Brachynectes Scott, 1957, *Trans. R. Soc. S. Aust.*, 80, 180. Type-species, *Brachynectes fasciatus* Scott.

Brachynectes fasciatus Scott, 1957

Brachynectes fasciatus Scott [T.D.], 1957, *Trans R. Soc. S. Aust.*, 80, 180, fig. 1. Type locality: Pelican Lagoon, Kangaroo Island, South Australia.

Verconectes fasciatus Scott [T.D.], 1962, MAR. FRESH. WAT. FISH. S. AUST., 255, fig. on page 256. *Id.* Scott, Glover and Southcott, 1974, MAR. FRESHW. FISH. S. AUST., 286, fig. p.286.

Brachynectes fasciatus: Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89 (1), 54. *Id.* Scott [E.O.G.], 1967, *Pap. Proc. R. Soc. Tasm.*, 101, 216; 1969, *Aust. Zool.*, 15 (2), 175.

Generic status. As observed above, *Verconectes* Whitley, 1931 — (unneeded) substitute name for *Trianectes* McCulloch and Waite, 1918 — is probably to be regarded as a synonym of *Tripterygion* Risso, 1826. Though shortly after its establishment *Brachynectes* was abandoned by its author, the feature from which it derives its name — second dorsal (X) shorter than third (13) — is incompatible with the traditional concept (Macleay 1882,

TABLE 5

Fosterygion multiradiatum sp. nov., holotype, paratype, *Forsterygion gymnotum sp. nov.*, holotype, five paratypes. Dimensions: first line, standard length, absolute, mm; all other lines as permillages of standard length.

Feature	*F. multiradiatum*		*F. gymnotum*					
	Holotype	Paratype	Holotype	Paratypes				
				(*a*)	(*b*)	(*c*)	(*d*)	(*e*)
Standard length	105.0	92.0	64.5	54.1	55.0	62.4	64.0	67.0
Total length	1143+	1174	1189	1203	1209	1207	1201	1185
Length to first dorsal origin	187	193	171	166	164	159	175	181
Length to first dorsal termination	256	272	281	296	291	272	298	294
Length to second dorsal origin	276	292	327	325	324	296	331	331
Length to second dorsal termination	710	707	659	723	704	697	688	703
Length to third dorsal origin	724	720	704	752	736	745	720	736
Length to third dorsal termination	910	934	953	961	947	987	984	985
Length to anal origin	443	457	465	482	509	495	481	472
Length to anal termination	926	950	961	961	965	987	984	985
Length to vent	429	433	443	460	484	478	459	451
Length to ventral origin	238	245	217	196	236	240	233	224
Length of inner ventral ray	200	185	175	189	191	176	198	172
Length of outer ventral ray	146	162	141	129	149	141	156	133
Length to pectoral, front of base	267	277	257	220	255	239	263	267
Length to pectoral, origin of middle ray	314	322	295	277	293	319	311	291
Length of pectoral, whole fin	257	293	326	355	320	308	297	304
Length of longest pectoral ray	219	229	278	262	271	256	266	258
Head	276	288	268	303	309	272	280	269
Snout	70	76	70	74	73	67	70	72
Eye	67	74	78	87	82	79	78	75
Interorbital	33	38	31	30	35	32	31	33
Depth, width at front of eyes	143, 173	141, 185	138, 194	129, 163	127, 155	96, 204	109, 214	119, 184
Depth, width at back of eyes	167, 210	185, 212	195, 231	181, 222	178, 200	194, 226	178, 241	175, 225
Depth, width at operculum	200, 190	226, 163	202, 186	213, 211	220, 200	208, 210	213, 209	187, 209
Depth, width just behind vent	200, 114	207, 130	216, 141	220, 129	218, 116	208, 119	219, 123	239, 134
Maximum depth, width of head	210, 210	207, 213	203, 239	222, 226	220, 227	212, 240	195, 238	209, 239
Maximum depth, width of body	190, 157	228, 174	222, 198	232 200	236, 185	221, 192	220, 188	222, 151
Minimum depth, width of caudal peduncle	84 , 19	84 , 20	91 , 16	100, 19	91 , 16	101, 16	94 , 16	94 , 16

p.26) of *Tripterygion*, which has the middle dorsal the longest. *Brachynectes* continued to be recognized in the name-list of Whitley (1964), a position with which the writer finds himself in agreement — see earlier discussions on this genus in Part XV (1967) and Part XVI (1969). The two papers by the present writer cited provide some additional general information and note differences exhibited by the Tasmanian examples of *B. fasciatus*, several of which suggest the desirability of some emendation of the original account and figure.

Additional material. Parts XV, XVI give metrical and other data for 7, 1 Tasmanian specimens (XV also 1 South Australian). Scott *et al.* (1974, p.286) report the species only from the type locality, Kangaroo Island. At and near the locality of the Part XI specimens, Greens Beach, north coast, it is rather common. Additional material in the collections of the Queen Victoria Museum comprises: Greens Beach, 1, *Ls* 35.1, *Lt* 42.4, 4 November 1966, Reg. No. 1972/5/350; 14, *Ls* 23.1-32.0, $\bar{x}$ 26.6 ± 0.814, *Lt* 29.2-39.6, $\bar{x}$ 33.6 ± 0.923, 13 January, 1968, 1972/5/431; 1, *Ls* 35.0, *Lt* 43.1, 11 September 1965, 1972/5/507; 1, *Ls* 28.2, *Lt* 33.4, 13 January 1968, 1976/5/28; 16, *Ls* 23.0-35.6, $\bar{x}$ 29.5 ± 1.10, *Lt* 30.3-46.2, $\bar{x}$ 38.1 ± 1.41, 13 January 1968, 1976/5/35: Kelso, Tamar river estuary, north coast, 3, *Ls* 26.3, 27.2, 34.1, *Lt* 34.0, 37.2, 41.5, 13 January 1968, 1976/5/35.

Length classes. With all Tasmanian examples for which data is available (43) pooled the frequency distribution of *Ls* in 14 length classes, 22.5-23.4 ... 35.5-36.4 is 3, 3, 6, 6, 1, 2, 2, 1, 2, 4, 2, 3, 5, 3. The distribution exhibits some indication of being trimodal at 25.5, 31.5, 35.5; these values may represent year classes. None of our examples closely approaches the conventional length given in Scott *et al.*, namely, 57 mm.

KEY TO TRIPTERYGIIDAE RECORDED FROM TASMANIA

1.	First dorsal with 7 spines	2
	First dorsal with 3 spines	3
2.	Margin of first dorsal ascending caudad to 6th spine, which is >1½ (1.8) first. Second dorsal with > 22 (24) spines. Anal with >28 radial elements (ii, 29). Upper lateral line ending below third dorsal. No naked strip flanking first dorsal	*Forsterygion multiradiatum*
	Margin of first dorsal subhorizontal; 6th spine ≤first. Second dorsal with <22 (20) spines. Anal with < 28 radial elements (i, 23-24). Upper lateral line ending below second dorsal. A naked strip flanking first dorsal ..	*Forsterygion gymnotum*
3.	Number of spines of second dorsal (18) > 2 number of dorsal rays (8)	*Tripterygion whitleyi*
	Number of spines of second dorsal (*ca* 10-24) <2 number of dorsal rays (*ca* 10-14)	4
4.	Head with some scales. Spines of second dorsal 13-14	*Gillias macleayana*
	Head naked. Spines of second dorsal either *ca* 10 or *ca* 16	5
5.	Number of spines of second dorsal (10) < number of dorsal rays (12-13). Two lateral lines. Upper lateral line ending under second dorsal	*Brachynectes fasciatus*
	Number of spines of second dorsal (16) > number of dorsal rays (11). One lateral line [?]. [Upper] lateral line ending under third dorsal	*Helcogramma clarkei*

Tasmanian Fishes

Family ECHENEIDAE

Of the eight species (representing seven genera) of Echeneidae accepted by Strasburg (1964), following Maul (1956), fewer than recognized by a number of writers, three are recorded in the Australian Check-list (McCulloch 1929), namely *Remora remora* (Linné, 1758), *Remilegia australis* (Bennett, 1840) [as *Remora*], *Echeneis naucrates* Linné, 1758; the list admits only the first as Tasmanian (as did both Johnston's first and second lists; as *Echeneis remora*). However, Lord (1923, p. 70, 1927, p.15) and Lord and Scott (1924, pp. 13, 83) list also *Echeneis naucrates*, but give no specific records of it.

KEY TO ECHENEIDAE REPORTED FROM TASMANIA

Moderately stout, depth 5-8 in *Ls*. Lower jaw not produced in a median flap. Anal base short, < length of disc; rays < 28 (23-25). Dorsal rays < 30 (21-27). Disc < 3.5 (2.6-3.1) in *Ls*; laminae 16-20. Pectoral rounded. More or less uniform brownish, greyish or blackish; no dark midlateral band ..... *Remora remora*

Slender, depth 9-14 in *Ls*. Lower jaw produced in a median flap. Anal base long, > length of disc; rays > 28 (30-38). Dorsal rays > 30 (32-41). Disc > 3.5 (3.8-4.3) in *Ls*; laminae 21-28. Pectoral pointed. Dark brown above, paler below; a broad blackish midlateral band from mouth to caudal base ..... *Echeneis naucrates*

Genus *REMORA* Gill, 1862

Remora Gill, 1862, *Proc. Acad. Nat. Sci. Philad.*, 14, p. 239. Type-species, *Echeneis remora* Linné (See Opinion 242, Internat. Comm. Zool. Nomen., 1954).

Remora remora (Linné, 1758)

Echeneis remora Linné, 1758, SYST. NAT., ed. 10, p. 260. Type locality: In Pelago Indico.

Material. Two examples, (*a*), *Ls* 341, *Lt* 411 (Q.V.M. Reg. No. 1976/5/54), (*b*) *Ls* 355, *Lt* 437 (Reg. No. 1976/5/53), collected at a depth of 460 m, 40 km east of Eddystone Point, east coast, Tasmania, on 5 February 1976 by Mr A.W. Yeates.

Host. The fish were taken from the undersurface of a Luth, *Dermochelys coriacea*. (Linné, 1776). *Remora remora*, like *Echeneis naucrates*, has a variety of hosts, other echeneids tending to be more specific (Lachner 1966). In a table of hosts of seven species, segregated by major groups of animals, Cressy and Lachner (1970, p.311) record in a compilation of field data that of 264 hosts of *Remora remora* 2 were sea turtles, the rest comprising 247 sharks, 1 manta, 14 teleosts. Data from the literature compiled by the same authors showed 12+ entries for sharks, with other entries (number unspecified, but fewer than 4) for sea turtles and for two groups of fishes. Of 13 examples of *Remora remora* examined by Strasburg (1964, p. 53), 7 were free-living, the remainder having sharks (4 species) as hosts. In any attempt to rank preferences the relative abundance of the host (together with ease of collection and availability of collected material for examination) must of course be taken into account: with reported cases equalling or exceeding those for teleosts other than Billfishes, turtles stand fairly high in the list. For the occurrence of the present host in Tasmanian waters see Scott and Mollison (1956a, 1956b), Green (1971).

Meristic characters. Disc laminae 17, 17. D. 23, 23. A. 24, 24. P. (left/right) 28/27, 28/27. C. 18, 18. As pointed out by Strasburg, definitive fin counts

(particularly that of the dorsal) are not readily obtained without removal of the thick leathery membrane. That procedure not being acceptable here, the best total that could otherwise be arrived at was obtained by feeling through the membrane, isolating rays as far as practicable by compressing it between them. The uppermost element of the pectoral, a short bony splint that has been reported as having a direct articulation with the girdle, is counted as a ray: attention may be called to a difference found in both individuals between the left and right fins. Counts for our specimens all fall within recognized ranges, which, as noted in available literature, are laminae 16-20 (mode, as found by Strasburg, 18). D. 22-26 (24), A. 21-25 (23), P. 26-30 (27). Munro (1967, p. 543) gives an unlikely P.23.

Dimensions as *TLs*. Smaller specimen (*Ls* 341) noted before larger (*Ls* 355): all 'length to' measurements from tip of lower jaw, which is in advance of upper by 19, 13 *TLs*. Length to tip of lower caudal lobe 1205, 1231, of upper lobe 1191, 1225; to tip of middle caudal rays 1117, 1168. Length to origin of disc, insertion 43, 29, free rim 38, 25; to termination, insertion, 311, 367, free rim 359, 352. Length to origin, termination of second dorsal 639, 611, 924, 887; of anal 592, 606, 908, 896. Length to origin of pectoral at front of base 240, 238, at insertion of median ray 273, 273; length of fin from base 170, 165; length of longest (4th, 3rd) ray 144, 139. Length to origin of pelvic 279, 262; length of spine 136, 144; for lengths of rays, see below. Length to vent 548, 566. Length of longest dorsal ray 141, 141, middle 97, 94, last 38, 44: of anal 155, 146; 100, 99; 31, 44. Interpectoral distance 170, 175. Oblique height of pectoral base 82, 85.

Head 252, 251. Snout 106, 99. Eye 26, 27. Interorbital 166, 166. Direct distance gape to orbit 26, 25; end of rictal groove to orbit 21, 18; superolateral border of head (dorsum here flat) to orbit 12, 17. Length to nostril 76, 97; internarial 175, 141; direct distance nostril to orbit 29, 30. Depth (in parentheses, width) at front of disc 44, 39 (111, 104), front of eye without disc 79, 77, with disc 100, 99 (161, 158), operculum, without disc 135, 132, with disc 161, 152 (185, 180), back of disc 161, 155 (161, 166), vent 158, 158 (141, 132): maximum 173, 161 (176, 169): caudal peduncle (minimum) 72, 68 (38, 34).

Head, trunk, tail. The anteroposterior extension of head, trunk, tail are such that when lengths to opercular border, vent and hypural joint are measured and their logarithms are plotted against logs 1, 2, 3 the points come close to being collinear. For (*a*) the best straight line is $\log L = 1.2501 \log N + 1.9434$; $t = 18.57$*: measured (predicted) lengths, mm, 89 (88), 201 (209), 355 (347): for (*b*) $\log L = 1.2395 \log N + 1.9246$; $t = 14.22$*: measured (predicted) lengths 86 (84), 187 (199), 341 (328).

Disc. *(i). Function.* The remarkable suctorial apparatus (generally regarded as a modification of the first dorsal fin) of the fish known to the Romans as Remora and to the Greeks as Echeneis that has attracted pipular attention since classical times has recently been the subject of structural, functional and developmental study by, among others, Bonnell (1961, 1964, 1966), Sewell (1925), Hora (1923, 1925), Norman (1943). As the outcome of investigations based initially on *Echeneis naucrates* but later extended to cover echenoids in general, the first-named author has suggested it may function also (perhaps even primarily) as an organ for the gathering of information. For an *ad hoc* demonstration of its adhesive capability see Scott (1962, p.263). Some incidental light is cast on the relative action of the fleshy rim (marginal flap of Bonnell 1961) and the tolerably rigid transverse laminae (a matter on which diverse views have been expressed) by the following observations. When one of the present fish, taken from formalin and allowed briefly to drain off, is placed on a sheet of paper, without pressure being exerted, a good liquid print of the periphery is obtained, together with partial prints, at the ends of the disc, of the central rachis and of some of the internal part of the laminae. On the application of a little pressure, complete prints of the laminae become evident as continuous lines without any clear indication of the comblike teeth — of which four well formed rows occur on most laminae,

several laminae at either end, however, having only three rows, or, transitionally, three and an imperfect fourth.

(ii). Length. The length of the disc relative to that of the pectoral has been employed in this family as a specific character; however, its taxonomic significance is qualified by differential growth in the two features. In a scatter diagram with absolute extension of adpressed pectoral plotted against *Ls* the data of Strasburg (1964, fig. 1) indicate that for about a score of individuals over the approximate *Ls* range of 30-150 mm the excess of pectoral length is about 0-2.5 mm, modally round 1.5, with no clear indication, within this range, of increase in value. However, an isolated plot for a specimen some 240 long shows an excess of about 15, or about 6.4% of *Ls*. In both our examples the adpressed pectoral extends beyond the level of the disc (free rim) by 23 mm, or 6.7, 6.5% of *Ls*, or 0.40, 0.39 total length of fin. The extension caudad of the pectoral and the pelvic are nearly the same, the former reaching beyond the latter by half, one-third of an eye diameter. The total longitudinal extension of the disc is from 1.5, 0.9 eye diameter behind tip of upper jaw to behind head by 0.40, 0.40 head length. At its attachment to the dorsum its maximum width (occurring at about two-thirds of its length) is 0.37, 0.39 its attached length; at its free rim 0.43, 0.49 its free length.

(iii). Form. The overall outline of the disc appears not to have been the subject of detailed attention. The outline of a liquid-print of the periphery has been traced in pencil, and its widths have been measured at tenths of the length. The widths have been fitted, for both specimens, with a second degree polynomial. With W = width (mm), N = decile number (counted caudad) the equations obtained are (*a*) $W = 18.77 + 10.598\ N - 0.9912\ N^2$; (*b*) $W = 29.96 + 10.426\ N - 0.9200\ N^2$. Measured and calculated values are set out in table 6. A third degree polynomial is found to yield, in either specimen, early values slightly above, later values well below, measured widths.

(iv). Spatial relation to dorsum. The measured distances between front and back of disc and front and back of head have been given above. It is of interest to observe that the anterior tip of the disc is located at the focus of the parabola formed by the upper jaw and the rest of the head behind it.

(v). Length-number pattern. An interesting length-number pattern is presented by the laminae. As here measured, length, mm, is that of the transverse vertical ridge bounded on either side by its line of junction with the oblique subovate fleshy tab that appears as if attaching it to the inner surface of the fleshy periphery of the cup. Lengths of the laminae from the most anterior backwards to the longest (9th, 11th) are denoted by L, and the serial numbers of these, counting caudad, by N: lengths of the remaining, posterior laminae are denoted by L_1, and their serial numbers, counting cephalad from the hindmost, by N_1. In each of the two sections of the fin an exponential relationship subsists between lengths and number, $L = bN^k$, $L_1 = bN_1{}^k$, conveniently treated as yielding linear graphs with equations $\log L = k \log N + \log b$, $\log L_1 = k \log N_1 + \log b$.

For (*a*) $\log L = 20.5223 \log N + 14.5445$; $t = 49.33$***: measured (in parentheses predicted) lengths 14.5 (14.5), 20.3 (20.7), 24.9 (24.3), 27.1 (26.9), 28.8 (28.7), 30.1 (30.5), 32.3 (31.8), 33.0 (33.1), 33.9 (34.1). $\log L_1 = 12.6108 \log N + 22.1651$; $t = 25.88$***: measured (predicted) lengths 22.0 (22.2), 26.0 (26.0), 28.5 (28.3), 29.6 (29.8), 31.0 (31.0), 31.8 (32.0), 32.8 (32.8), 33.7 (33.6).

For (*b*) $\log L = 24.0869 \log N + 14.2563$; $t = 143.27$***: measured (predicted) lengths 14.3 (14.3), 21.3 (21.5), 26.0 (25.7), 29.0 (28.8), 31.1 (31.1), 32.7 (33.0), 34.4 (34.6), 35.8 (36.0), 37.2 (37.2), 38.6 (38.3), 39.5 (39.3). $\log L_1 = 12.7766 \log N_1 + 27.1968$; $t = 11.90$***; measured (predicted) lengths 27.0 (27.2), 31.3 (31.0), 33.0 (33.3), 35.3 (34.9), 36.0 (36.1), 37.1 (37.2).

Head in plan. For both specimens outlines have been traced of the head in plan, viewed both from below and from above, the anterior part of the parabolic curve being provided by the lower jaw and the upper jaw, respectively. The data for each fish have been fitted with a second degree and also with a third degree polynomial. With W = width (mm), N = decile number, counting caudad, the equations for (*a*) are, lower jaw, $W = 23.65 + 9.693\,N - 0.5689\,N^2$; $W = 13.52 + 18.586\,N - 2.4932\,N^2 + 0.11662\,N^3$: upper jaw, $W = 27.11 + 9.175\,N - 0.5436\,N^2$; $W = 18.91 + 16.409\,N - 2.1089\,N^2 + 0.09487\,N^3$. For (*b*), lower jaw $W = 29.93 + 9.671\,N - 0.5833\,N^2$; $W = 24.28 + 14.619\,N - 1.6606\,N^2 + 0.06529\,N^3$: upper jaw, $W = 25.86 + 11.777\,N - 0.7708\,N^2$; $W = 34.45 + 4.2125\,N + 0.8678\,N^2 - 0.09920\,N^3$.

Measured and predicted values of W are set out in table 6.

The tip of the upper jaw is close to the locus of the parabola formed by the lower jaw and the rest of the head.

Pelvic. Equations for log lengths of pelvic rays plotted against logs of their serial numbers are: (*a*) $\log L = 0.3396 \log N^1 + 1.4597$; $t = 25.80$***; measured (predicted) lengths 29.0 (28.8), 36.1 (36.5), 41.4 (41.9), 47.1 (46.1), 49.5 (49.8): (*b*) $\log L = 0.3371 \log N^1 + 1.4878$; $t = 30.63$***; measured (predicted) lengths 30.8 (30.7), 38.8 (38.8), 44.0 (44.5) 50.0 (49.1) 52.5 (52.9). By a convention adopted in Part XIX (1974a, p. 248) first ray is that farthest from the spine (here, shortest).

Coloration. More or less uniform gun metal grey, with in parts some hint of reddish; in (*a*) a trifle dark; operculum somewhat darker, membrane brownish. Upper surface of disc rim lighter with some off-white mottling; lower, concealed surface light brownish mottled white in (*a*), largely whitish with some reddish brown flushes, partly brownish with a little white anteriorly in (*b*); laminae mainly greenish grey, with some light spots and blotches, fleshy tabs joining ridges to cup wall bluish grey, most with small whitish blotch at base and at tip. Dorsal mostly concolorous with tail; in (*b*) a narrow light greyish margin. Anal concolorous with tail in (*a*), in (*b*) the same basally, light greyish external to a line joining middle of anterior ray to base of last ray. Pectoral in (*a*) concolorous with trunk, except for uppermost ray, which is mottled with white proximally; in (*b*) distal one-third (left), half (right) lighter. Ventral greyish at tip. Caudal gun metal in basal half or so, thereafter lighter, save for an obscure darkish arc near tips of median rays. Branchiostegal membrane with hind one-third reddish brown mottled grey; in (*b*) with a few light spots. Some whitish vermiculation on left cheek in (*a*).

Specimen (*a*) exhibits some curious markings quite unrepresented in (*b*). These take the form of lines of white or grey spots, well rounded, 0.5-2.5 in diameter, adjacent ones subequal. On the left side, on which they are less conspicuous, more greyish, they include: three rows (plus a dozen scattered spots) on outer surface of pectoral; a sinuous line from near pectoral tip to meet the dorsal and to continue along its fleshy anterior border; a line from near middle of lower pectoral border down and back almost to midventral line near pelvic tip, thence running back and up to within a little more than an eye diameter of dorsal base at first one-fifth of its length, thereafter descending to midlateral line about at anal termination; some spots, in places briefly forming lines, between pectoral and pelvic and on ventral surface in advance of origin of latter. On right side a line of about ten from anterior one-third of upper border to last one-fifth of lower pectoral border, the general line continued back on the trunk by 15 spots in an upwardly convex arc to midlateral line, thereafter extending back in about 40 spots to shortly in advance of anal termination, followed, after a brief hiatus, by a short, more dorsally set line of 6 spots; a line from just in advance of middle of lower pectoral border almost to midventral line, at level of last one-fifth of fin, thence, just to right of middorsal line, to dorsal origin, continuing along more than one-third base, then ascending on to the membrane to end near middle of distal border of fin. Spots occur on the inner (postaxial)

TABLE 6

Remora remora (Linné, 1758). Widths, mm, at tenths of anteroposterior extension, as measured and as calculated from second degree and third degree polynomials given in the text, of disc, of head with lower jaw constituting the curve anteriorly, and of head with upper jaw constituting the curve anteriorly: standard lengths (*a*) 341 mm, (*b*) 355 mm.

Disc				Head including lower jaw						Head including upper jaw					
(*a*)		(*b*)		(*a*)			(*b*)			(*a*)			(*b*)		
Data	2nd degree	Data	2nd degree	Data	2nd degree	3rd degree	Data	2nd degree	3rd degree	Data	2nd degree	3rd degree	Data	2nd degree	3rd degree
28.8	28.4	29.7	30.4	31.0	32.8	29.5	37.0	38.6	37.3	34.0	35.7	33.3	35.0	36.9	39.5
36.7	36.0	39.5	38.1	42.3	40.7	41.5	48.0	46.9	47.4	43.1	43.2	44.1	49.0	46.3	45.5
40.5	41.7	44.4	44.0	48.0	47.6	49.8	55.0	53.6	55.0	50.9	49.7	51.7	56.2	54.2	52.2
44.5	45.3	47.1	47.9	54.0	53.3	55.2	60.5	59.2	60.4	57.0	55.1	56.7	61.0	60.6	58.8
46.5	47.0	49.0	50.1	58.8	57.9	58.5	63.5	63.5	64.0	59.9	59.4	60.1	64.5	65.8	64.8
47.0	46.7	49.9	50.4	61.0	61.3	60.3	66.0	66.8	66.3	62.0	62.6	61.9	67.2	68.8	69.5
45.5	44.4	50.1	48.9	62.5	63.6	61.3	68.0	68.8	67.6	63.3	64.7	63.0	68.3	70.5	72.4
41.9	40.1	46.9	45.5	63.5	64.8	62.1	68.5	69.7	68.4	64.3	65.8	63.8	69.0	70.7	72.9
35.0	33.9	39.0	38.8	64.4	64.8	63.7	69.0	69.5	68.9	65.5	65.7	64.9	70.1	69.4	70.3
	-	-	-	65.1	63.7	66.5	69.5	68.0	69.7	66.5	64.5	67.0	69.2	66.6	64.1

surface of both pectorals, a score (including two large) on left, upwards of two score forming three lines, one of which extends whole length of fin. On both sides an imperfect line between eye and upper end of pectoral base; a few below eye, a number bordering base of disc, more nearly continuous around posterior half.

Family SYNANCEJIDAE

This family, which includes the venomous stonefishes occurring in northern Australia and having a wide extralimital distribution, is represented in the southern States by a single genus, *Glyptauchen* Günther, 1860, originally referred by Whitley (1931) to a separate family, Glyptauchenidae (not noticed by Greenwood *et al.* (1966) in their provisional classification of the Teleostei), a position he later abandoned (1962). The genus, which is endemic to Australia, was long regarded as monotypic, but has been divided by Whitley (1931) into two species, each with two subspecies that are noted as being typical of well-marked zoogeographical regions. In terms of the currently accepted taxonomic positions, the validity of which remains somewhat problematical, the Tasmanian goblin fish is *Glyptauchen insidiator mirandus* Whitley, 1931.

Genus *GLYPTAUCHEN* Günther, 1860

Glyptauchen insidiator Whitley, 1931

Glyptauchen insidiator Whitley, 1931, *Rec. Aust. Mus.*, 18 (3), 118, pl. 14. Type locality (of nominate subspecies): Kurnell, Botany Bay, New South Wales.

Glyptauchen insidiator mirandus Whitley, 1931

Glyptauchen insidiator mirandus Whitley, 1931, *Rec. Aust. Mus.*, 18 (3), p. 120. Type locality: Tasmania.

Glyptauchen panduratus: Johnston, 1883, *Pap. Proc. R. Soc. Tasm.* (1882), p. 114; *ibid.*, 1891 (1890), p. 31. *Id.* Lord, 1923, *Pap. Proc. R. Soc. Tasm.* (1922), p. 70; 1927, *J. Pan-Pac. Res. Inst.*, 2 (4), p. 15. *Id.* Lord and Scott, 1924, SYNOP. VERT. ANIM. TASM., pp. 13, 85. *Id.* McCulloch, 1929, *Aust. Mus. Mem.* 5 (3), p. 391 (Tasmanian record only). Not *Apistes panduratus* Richardson, 1850.

Material. A specimen, *Ls* 64, *Lt* 81, collected 2 km north of Greens Beach, northern Tasmania, on 18 April 1976 by Mr R.H. Green; Q.V.M. Reg. No. 1976/5/127.

Habits. Goblin fishes are seldom collected — 'I have seen only one specimen' (Castelnau 1873, p. 63); in his survey of the genus Whitley (1931) noticed only the holotype of each of the two subspecies of *G. insidiator*; the present example is the first that has come under the notice of the writer — and very little is known regarding their habits. In view of the statement by Whitley 'They are probably sedentary, carnivorous fishes of the rocky zone beyond tidal limits', it is of interest to note the fish here reported was taken in a rock pool at about one-tenth of the littoral range above low water mark. Mr K.J. Atherton informs me that in the course of a scuba dive in George Bay, east coast, in May 1976 he observed a goblin fish of an estimated total length of about 13 cm, swimming at an estimated depth of 8 m. Modal total length is apparently about 100-150 mm; the largest recorded specimen reached 200 mm.

Meristic characters. Br.7. D.XVI/I,7. A.III,6 (what are here counted as the 5th and 6th rays may possibly be the two rami of a single ray, split to base; they lie close together throughout their length, and as far as can be determined without dissection remain distinct). P.14/14. V.I,5. C.15 (11 reaching to hind border). Lat. 1. 27 + 1 on caudal base on left side. About 45 rows of scales between scapular spine

and hypural joint. About 30 scales counting obliquely upward and forward from vent.

Dimensions as *TLs*. Total length 1266. Length to origin, termination of first dorsal 284,805, of second dorsal 828,945, of anal 688,911. Length to origin of pectoral at front of base 297, at insertion of middle rays 398; total length of fin 439; length of longest (4th) ray 375. Length to origin of ventral 359; total length of fin 309. Head 414. Snout 78. Eye 109. Interorbital 109. Depth (in parentheses width) at front of eyes 195 (156), back of eyes 239 (258), occipital depression 217 (258), operculum 313 (234), vent 320 (172); maximum, head 305 (313), body 344 (234); caudal peduncle 109 (19).

Absolute lengths (mm) of spines and rays of all fins other than caudal are included in data on length-position relationships of radial elements discussed below.

General description. Published information on the external features of *Glyptauchen insidiator mirandus* is confined to the original account of the holotype, which is concerned in large part with differences from the nominate subspecies; references in local lists (Johnston 1883, 1891; Lord 1923, 1927; Lord and Scott 1924) being merely reports of occurrence. Supplementing the purely numerical data recorded above, a general account of the Tasmanian form, taking note of all features dealt with in the definitive description of the holotype of the typical subspecies (Whitley 1931), is here offered. Items in square brackets relate, if unmarked, to the holotype of *G. i. mirandus*, if marked *i* to the holotype of *G. i. insidiator*.

Approximate number of transverse series of scales between scapular spine and hypural joint 45 [40; *i* 30]. Head 2.42 [2.83; *i* 2.48], greatest depth 2.91 [2.73; *i* 2.83] in *Ls*. Eye 1.0 [*i* equal to] interorbital. Larger preopercular spine 4.62 [*i* 4.82] in head, shorter [*i* shorter] than upper opercular spine, 3.73 [*i* 4.56]. Longest, 6th [9th; *i* 9th] dorsal spine 1.62 [1.83; *i* 1.95] in head. Height of soft dorsal 1.91 [*i* 2.16], of anal 1.74 [*i* 1.91] in head — both our measurements taken obliquely, representing length of longest ray. Caudal 1.56 [*i* 1.58] in head.

Dorsal profile subvertical, very gently convex, to level of front of orbit; virtually horizontal to just behind level of back of orbit; descending vertically to form anterior border of the characteristic occipital excavation; floor extending horizontally, about at level of upper border of pupil, for about one pupil diameter; posterior border rising steeply, slightly convexly; a short dip between its end and dorsal origin; a single moderately convex arc, height of chord about one-tenth length, below dorsals; caudal peduncle somewhat concave. Ventral profile to just past middle of eye shallowly sinuous; virtually a single moderately convex sweep to anal termination, with some measure of flattening between ventral and anal fins; caudal peduncle somewhat concave. Dorsal profile noticeably less arched than as depicted for *G. i. insidiator* (Whitley 1931, pl. 14), its curve more nearly approaching, but being a trifle more convex than, that of the standard figure (Richardson 1850, pl. 1) of the typical Western Australian *G. panduratus panduratus* (figure used in Scott *et al.* 1974, to illustrate the South Australian subspecies, *G. p. deruptus* Whitley, 1931). Head entirely naked: much of it plicate, vermiculate, minutely mammillate, or in brief linear segments crenulate. Its height at middle of eye equal to height at middle of occipital depression, and to postorbital length; width equal to length without snout; length of supraorbital platform subequal to direct length from its front edge to upper lip.

A typical cottoid bony genal stay, originating close below, shortly in advance of, orbit near 9 o'clock (left side viewed), extending almost horizontally, passing close to orbit, to become continuous with uppermost spine of preoperculum: comprising (*a*), on preorbital, a roughly rectangular elevated area presenting a short but stout cordate spine directed down and back, overhanging maxilla near middle of its length, and a somewhat smaller boss about below nostril, the two connected by an irregular

elevation traversed by a longitudinal crenulated crescentic ridge; (*b*) a large curved spine, originating near base of spine of (*a*), extending back and slightly down nearly to level of front of pupil, a median ridge, on left side minutely crenulate; (*c*) a smaller spine, originating near middle of (*b*) between it and orbit, partly in contact with it and extending beyond it; (*d*) a downward and backward continuation of the anterior arc of the circumorbital rim, swinging out from orbit near 4 o'clock (left side viewed) and continuing down and back on to cheek at an angle of some 40°, beginning as a thin ridge, broadening, behind middle of pupil, to constitute a spine, tip curving down towards lower half of interval between first (uppermost) and second preopercular spines, whole structure enveloped in membrane; (*e*) wedged in between (*d*) and bottom of orbit a slender almost horizontal spine, its median ridge an offshoot of extended orbital ridge near point at which it departs from orbit; (*f*) a rather small straight (right) slightly curved (left) spine, originating just beyond (*d*) and in the same general line as that spine before it curves down terminally, wholly or almost wholly borne on base of the (much larger) uppermost preopercular spine, its own base in contact above with a slightly preconvex, generally subvertical buttressing ridge beginning about at level of lower one-third of eye, regularly increasing in height as it descends. This genal stay is not expressly referred to in the original descriptions of *G. i. insidiator* and *G. i. mirandus*, and the only elements of it receiving mention (in the nominate subspecies) are (*a*) and (*b*), on the preorbital, the latter (in our example ensheathed in membrane) being noted as erectile. As depicted in the figure of *G. i. insidiator* (which shows an apparently continuous subhorizonal bony ridge from below middle of eye backward, but presents a possible indication of only one small spine) (*b*) has much more the character of a large simple free spine than in our fish; this is true also of the figure of *G. p. panduratus*.

Arising above upper lip, about a lip width from it, occupying whole region between nostrils, two large thumb-like spines, subvertical in lower half, bowed backward above, extending to level of front of orbit; contiguous in middle half of length, slightly divergent proximally, markedly divergent distally; proximal six-sevenths wholly enveloped in black vertically plicate integument, blunt tips naked, rugose, bright pink [described for *G. i. insidiator* as nasal spines ending in two knobs]. Externad of the nasal spine, originating a little above level of its base, separated from it by the whole narial area, a spine curving up and back, its chord at about 40° to horizontal, to constitute circumorbital rim between 9 and 11.30 o'clock (left side viewed), ending above in an obtuse free point, from the base of which a supraocular shelf continues backward, but little curved, to level of hind border of eye, two blunt projections in its course and a terminal one; beyond last, rim continues back and down to end, in lateral view, as a short straight segment extending back horizintally behind orbit to constitute rest of side wall of dorsal cephalic platform. This remarkable platform, extending from level of tips of nasal spines to just beyond hind border of orbit, grossly trapezoidal or lyrate; anterior, posterior borders 0.7, 0.9 of fore-and-aft extension, the last 0.32 head; virtually linear lateral border constituted by supraorbital ridge, anterior border somewhat proconvex, formed as far as tips of nasal spines by a curved continuation of front of supraorbital ridge, hind border by two convex ridges with median notch; whole structure overall plane, but with raised rims as noted (not, narrowly, between nasal spines), and two strong acute longitudinal ridges arising immediately behind tips of nasal spines, diverging backward, finally continuous with posterior rim midway between notch and corner; markedly overhanging ocular region, forming shelf above floor of occipital depression.

Preoperculum with five main spines: first (uppermost) strongest, straight, at end of genal stay, last spine of which overrides its base, extending horizontally halfway to opercular border, a second minute spine at lower border of base; second about half length of first, below last genal spine, subequal in length to it, a very minute sliver of bone, resembling exposed tip of main spine just below its base; third small, below curved tip of penultimate genal spine; fourth smaller, a little closer to third than third to second; fifth, at lowest point on border, flat obtuse, broadly triangular: between fifth spine and angle of mouth a semicylindrical elevation that may perhaps

represent a rudimentary, adnate spine. On the broad longitudinally striated opercular lobe two long slender high, largely adnate spines, first slightly curved, inserted near preopercular border above base of uppermost preopercular spine by a distance subequal to length of that spine, running out and somewhat down to branchiostegal membrane, its length slightly greater than eye diameter; second originating immediately above first, a little behind it, similar in general form and size, running back and very slightly up to end just beyond first, but short of opercular border. Line of upper margin of membranous opercular angle continued forward by a flat adnate spine, wider than, about half as long as, the opercular spines; followed anteriorly by a similar spine with pronounced medial ridge, extending to within half its own length of orbit. Immediately above these spines three large broad, ridged petiolate spines: hindmost below interval between first and second dorsal spines, beneath fin base by little more than its own length, with two pronounced medial ridges; next basally in contact with hindmost, smaller, its tip beneath insertion of first dorsal spine, its upper border briefly constituting the dorsal profile immediately in advance of dorsal fin; foremost a slightly larger spine with strongly elevated borders met by a strong medial ridge, arising directly from hinder part of floor of occipital depression, immediately in front of second spine and intimately associated with it (on left side partly overlapping it, on right side with ridge constituting its posterior border continuing on to adjacent spine, there becoming confluent with medial ridge of latter): the inner borders of the front two spines, separated basally by about a third of an eye diameter, standing high above dorsum, their subvertical walls flanking a rectangular trough, a little longer than wide, extending from occipital depression to just in advance of insertion of first dorsal spine, the floor rising steeply backward. A strong blunt scapular spine, adherent for most of its length, overlapped basally by membranous opercular flap; with several curved basal ridges, in large part minutely crenulate.

[What are here spoken of as the anterior two of three spines near dorsal origin are treated in account of holotype of *G. i. mirandus* as a single spine 'almost divided' so as to have two points. This certainly represents a tenable interpretation of the situation on left side of fish; however, on right side the two elements, though contiguous, seem more clearly to be characterizable as separate entities — a suggestion supported by the general similarity of each element both to the adjoining spine, and, as noted below, to spine of first lateral line scale.]

Snout with anterior profile steep, twice as wide as long, shorter than eye. Eye large, 3.8 in head, equal to interorbital, posterior part of shelf-like supraorbital ridge briefly constituting dorsal profile, barely above interorbital ridges here. Mouth small, gape about 45°, maxilla considerably expanded posteriorly, greatest width subequal to direct distance from orbit, or about half eye; reaching just to orbit [*G. i. insidiator*, below anterior third eye]. Throughout most of its extent integument of lower lip depends below lip in a flap, deepest near middle of mandible, here almost one-third length of latter. Teeth in upper jaw villiform, in a band of about 8-10, band subequal in width for most of its length, narrowing rather abruptly in posterior one-fifth. Teeth in lower jaw villiform, in two bands divided by narrow bare symphysial ribbon, width of band subequal to that of upper jaw, greatest width just behind anterior one-third of length, only slightly narrower near symphysis, narrowing to slender pennon in posterior half. Teeth on palatines and on vomer villiform, in both cases in a band not greatly narrower than bands in jaws, palatine and vomerine series virtually continuous. A well developed palatal frenum, its attached border in contact for most of its extent with dental band, its free border gently sinuous; covered with microscopic vertical ridges.

Nostrils exceptionally large and complex externally. Anterior midway between orbit and midfrontal line, flanking large nasal spine, circular narial opening at level of middle of eye: the external structure is essentially a trumpet with a large reflexed lobe attached; trumpet flaring widely, its distal twice its proximal diameter, latter equal to its height, free outer margin running unbroken from 7 o'clock (left

side viewed) anticlockwise almost to 7 o'clock where it becomes continuous with the free margin of a fold arising from base of tube near 12 o'clock, this border then swinging outwards and upwards to the left to delimit a large somewhat reniform lamella, greatest (vertical) extent rather more than half eye, extending above trumpet rim by about trumpet diameter, border continuing downward and inward; broadening out from a sheet to a three-dimensional mooring to become confluent with both base and rim of trumpet near 12 o'clock. Opening of posterior nostril above, slightly externad of, that of anterior nostril; external structure (largely hidden in frontal view by large lamella of anterior nostril when erect) a tall cylinder, the two free subvertical borders convex, either, as on right side, diverging widely, and, with upper border sinuous, presenting a somewhat ear-like appearance, or, as on left side, doubly involuting to form two contiguous tubes; base of outer fold inserted slightly below that of inner; height about one and a half times width, about half pupil.

Floor of occipital depression bounded on each side by the anterior of the two spines continuing forward general sense of upper opercular border; divided by a pair of low longitudinal ridges into three subequal strips; inner two-thirds of middle strip becoming the predorsal interspinous trough. Branchiostegals seven, sixth and seventh small, close together. Gill membranes free, united across isthmus.

Most of the body covered with large imbricate cycloid scales, where present below smaller. Naked areas: whole of head; a strip, narrowing posteriorly, along spinous dorsal base (skin here largely logitudinally plicate); lateral surface in advance of a proconcave arc joining origin of lateral line and base of innermost ventral ray; ventral surface forward of half a dozen strong transverse plications immediately behind insertion of ventral; all fins; pectoral base. Lateral line descending slowly, evenly to level of vent, thereafter approaching horizontal; each scale bearing a well developed spine, anterior larger, more erect; no pore detected [no rounded flap as described for *G. i. insidiator* recognized]; first scale and its spine, situated between and close behind hinder spine collinear with upper pectoral border and outer petaloid spine below dorsal origin, much smaller than, but rather similar to, these, the similarity recognizable, but less pronounced, in next few spines also.

For fin counts see Meristic characters, above; for lengths of all spines and all rays other than caudal see sections on length-number patterns, below. Dorsal originating behind occipital depression, above middle of postorbital head; base 1.54 in *Ls*; soft base 4.44 in spinous [about 4; *i* about 6]: anterior spines shorter, stouter than as depicted for *G. p. panduratus*, more closely approaching those figured for *G. i. insidiator*. Anal originating below 13th dorsal spine, terminating with very brief membranous attachment below 6th [last] dorsal ray; base 1.91 base of soft dorsal; spines stout, third measurably longer than second, but not projecting far beyond it. Pectoral large, reaching to anal origin; measured with base just longer than, without just shorter than, head; all rays divided except uppermost, tips of upper subtriangular, flattish, of lower digitiform; 6th longest; general outline a continuous curve [as in figure of *G. p. panduratus*], upper two rays not abruptly trucate [as in figure of *G. i. insidiator*]. Ventral broadly based, rounded, spine inserted below 4th [in advance of 5th; *i* below 5th] dorsal spine, extending as far as pectoral. Caudal with major part of hind border, constituted by rays 2-9 of the 11 main rays, truncate, remaining rays shorter; greatest extent of distal divided portion (found in middle rays) rather less than one-fourth ray length; slender terminally pointed pads extending briefly up bases of most rays, on left two median much the largest, flanking last lateral line scale (bearing tubule, no spine), on right still larger median cushion, interradial, without tubule.

Coloration. The coloration is highly complex, exhibiting at once many strongly contrasting areas and many delicate gradations. Notes on the specimen made shortly after preservation in alcohol are here summarized.

Head. Chiefly black, with exceptions as follows: (*a*) light greyish patch extending back from mouth to include lower half of branchiostegal membrane; (*b*) upper half of operculum light fawn, lightest at angle, a conspicuous central splash of deep pink, with some diffuse continuation above, recumbent spines banded deep and light grey; (*c*) upper lip with a row of 5 small pinkish patches in mesial one-third, rest blackish; (*d*) lower lip light grey, the dependent flaps blackish, small pinkish area below symphysis; (*e*) frontal region with several quite small pinkish markings, tips of nasal spines bright pink, remainder black; (*f*) orbital platform dusky flesh, minutely dotted white; (*g*) occiptal depression largely pink, somewhat silvery in front, the mesial trough black, the small region between it and base of first dorsal spine fawn with touches of pink; (*h*) most of ventral surface immaculate, dusky with tinge of greenish; (*i*) preopercular and genal spines mainly black or blackish, their tips where exposed light grey; (*j*) two spines collinear with upper opercular border variegated with pastel tints of light grey, dark grey, white, pink; (*k*) spines between (*j*) and dorsal base brownish or deep fawn proximally, lighter distally, with some touches of pink.

Body. General colour of lateral surface dark brown, gradating into black, four conspicuous markings: (*a*) a conspicuous ovoid white spot just behind scapular spine; its major axis subequal to eye, running back and slightly up; (*b*) small white spot, having almost a glazed appearance, half a pupil diameter down from dorsal profile below interval between 4th and 5th spines; (*c*) similar spot between 11th and 12th spines; (*d*) behind a line running down and slightly forward between insertions of last rays of dorsal and anal a sharply contrasting wide bar of slightly dusky deep fawn, its anterior border narrowly pink (this marking continuous with light areas on dorsal and anal). Ventral surface between anal and ventral fins smoky, in advance of this somewhat lighter greyish.

Fins. Spinous dorsal chiefly dark blackish brown; a pinkish area on proximal part of membrane, and, less pronounced, on spines back to 9th spine, highest, about half fin, between 2nd and 5th spines; oblique pink strip, nearly an eye diameter wide, from near tip of 8th spine to near base of 14th; some small distal smudges of pink in hind half of fin. Soft dorsal with proximal one-third black, middle one-third white, with short brownish bars along ray borders for about one-fourth to one-fifth of their length, the anterior border of this region pinkish, directly continuous with pink border of caudal peduncle marking; distal one-third blackish, one small pink spot, briefly pinkish at tip. Anal similar to soft dorsal, pink border of light region again continuous with that on caudal peduncle. Pectoral largely dark brownish; lowest five rays black, white at very tip; proximal half of upper half of fin very complexly patterned with small pink, white and grey markings, the best defined short longitudinal bands; some pinkish diffusing back from this area towards hind border; tips of rays white. Ventral almost uniformly black. Distal one-fourth of caudal membrane dark brown; rest pure white between median rays, whitish very faintly tinged brownish between outer rays; for more than basal half of their length inner rays dark brown or black, outer grey, then with one or two rather obscurely formulated short light cross bars, thereafter brownish, deepening distally to blackish, extreme tips grey.

Length-number patterns of rays and spines. (*a*). *Dorsal spines.* The lengths of the dorsal spines and their sectional serial numbers are found to yield satisfactory linear graphs when the absolute length is plotted against the logarithm of the serial number. The pattern, comprising one ascending and two descending sections, is an exceptional one in two respects. First, it is the absolute, not as is commonly the case the logarithmic, length of the spine that is a linear function of its serial number. Secondly, whereas the usual situation in the descending portion of the fin is that where there are two (or more) sections each constitutes a separate entity such that, with its members counted in reverse (cephalad) and their lengths plotted against the logarithms of these inverse ordinal numbers (N^1), the resultant graph is linear, ascendant, in the present instance the two descending sections are not such separate entities, but are linked in such a way that the appropriate cephalad count begins with the last (16th)

spine of the fin and continues without interruption to the front spine of the first descending section (7th), which thus comes to be on log 10, there accordingly being, instead of the two ascending graphs each beginning at log 1, a single ascending graph with a point of inflexion at the end of the first and the beginning of the second section (here on log 3).

The equation for the ascending spines {x/x = I-VI} is L = 13.93 log N + 4.57 ;t = 33.39***; measured (in parentheses predicted) lengths, mm, 4.5 (4.6), 8.7 (8.8), 11.3 (11.2), 13.4 (13.0), 14.0 (14.3), 15.3 (15.4). For the anterior set of descending spines {x/x = VII-XIII} , L = 8.580 log N^1 + 4.50 ;t = 22.52***; 9.7 (9.7), 10.5 (10.5), 11.0 (11.2), 11.9 (11.7), 12.2 (12.2), 12.8 (12.7), 13.0 (13.1): for {x/x = XIV-XVI} , L = 6.326 log N^1 + 5.33 ;t = 29.13*; 5.3 (5.3), 7.3 (7.2), 8.3 (8.3). With as abscissal values the common logarithms of the relevant natural numbers and as ordinate values spine lengths in mm derived by calculation from the three equations (thus achieving some convenient smoothing), the areas under the curves are, in sequence backwards 7.66, 4.53, 3.27, *i.e.*, the area under the ascending segment is equal, to a good approximation, to the sum of the areas under the descending segments.

(*b*). *Dorsal rays.* With log ray length on log serial number (N) or log inverse serial number (N^1) for sets {x/x = 1-3} , {x/x = 7-4} the parameters of log N, log N^1 are 0.1384, 0.5724, the independent terms 1.0786, 0.6988 ;t 15.86*, 59.71***; measured (calculated) lengths 12.0 (12.0), 13.4 (13.2), 13.9 (14.0); 11.5 (11.1), 9.5 (9.4), 7.1 (7.4), 5.0 (5.0). Areas under ray intervals 1-2, 2-3 are approximately equal (0.331, 0.299); those under intervals 7-6, 6-5, 5-4 are approximately in the ratio 1:1:½ (0.236, 0.243, 0.126): no direct value is of course available for the interval between rays 3 and 4; however extrapolations of the equations yield in each case a one-half value (0.154, 0.128).

(*c*). *Pectoral rays.* Three sets are recognized, one ascending {x/x= 1-4}, and two descending {x/x = 10-5} , {x/x = 14-11} . With arithlog plotting, as for dorsal spines, the respective coefficients of N, N^1, N^1 are 14.563, 10.446, 7.148, the intercepts on the ordinal axis 14.85, 13.96, 7.28 ;t = 15.89**, 35. 27***, 129.25***; measured (calculated) lengths of rays 15.0 (14.9), 19.1 (19.2), 21.4 (21.8), 24.0 (23.6); 21.9 (22.1), 21.3 (21.3), 20.5 (20.3), 19.0 (18.9), 16.9 (17.1), 14.0 (14.0); 11.6 (11.6), 10.7 (10.7), 9.4 (9.4), 7.3 (7.3). In successive graphs the mean area below the curve in one interval is approximately in the ratio 4:3:2 — actual areas, followed in parentheses by areas calculated by taking the mean of the total area considered (intervals 4 -5, 10-11 not represented in graphs) as unity, and assuming the indicated ratio, being 1.890 (1.905), 2.818 (2.857), 3.860 (3.809).

(*d*). *Anal rays.* The first three rays form an ascending, the last three a descending, series. Equations: log L = 0.09837 log N + 1.1171 ;t = 43.47*; lengths 13.1 (13.1) 14.0 (14.0), 14.6 (14.6); log L = 0.4661 log N^1 + 0.7389 ;t = 31.38*; 5.5 (5.5), 7.5 (7.6), 9.2 (9.1). With length sets of as few as 3 members, plotted against logs 1-3, it is possible for both loglog and arithlog graphs to yield linear fits that are formally significant. This is the case in one instance here, t values for arithlog formulations being 28.44*, 9.65 ; the first equation (L = 3.127 log N + 13.09) giving calculated lengths equal to measured values.

(*e*). *Anal spines.* Equation: log L = 0.3829 log N + 0.9595 ;t = 78.75**; lengths 9.1 (9.1), 12.0 (12.0), 14.0 (14.0). The areas under the graphs are approximately in the ratio 3:2 (0.307, 0.196).

(*f*). *Ventral rays.* A log length-log number relation subsists for the set {x/x = 1-4} ; log L = 0.3654 log N + 0.9684 ;t = 28.47***; lengths 9.3 (9.3), 11.9 (12.0), 14.1 (13.9), 15.3 (15.4). The first ray is defined as that farthest from the spine (Part XIX, 1974, p. 248). Measured lengths of spine, fifth ray (for which an equation is trivial) are 11.1, 12.0 mm. The area under the graph of the interval between rays

1 and 2 (0.374) approaches equality with the sum of the corresponding intervals between rays 2 and 3 (0.207) and rays 3 and 4 (0.146).

Discussion. In a number of cases in which a comparative datum is available this has been incorporated in the foregoing account. Some differences disclosed are evidently attributable to individual variation. Attention may here usefully be called to features to which taxonomic significance has been attached in relevant specific and subspecific diagnoses.

In the diagnosis of *G. insidiator* it is noted as differing from *G. panduratus* chiefly in having (*a*) a much more arched back, (*b*) deeper body, (*c*) shorter anterior dorsal spines, (*d*) fewer and smaller preopercular spines, (*e*) fewer (2 instead of 3) distinct spines on either side near dorsal origin, (*f*) longest dorsal spine 9th (*cf.* 7th); (*g*) differently arranged colour pattern. With the situation interpreted on the basis of published data (not on examination of actual material), our specimen is found to provide no support for (*a*), (*b*), (*e*); it is in agreement for (*c*) and probably for (*g*). With respect to (*d*) our specimen occupies a somewhat anomalous position, the definitive marginal spines numbering 5 as in *G. insidiator* (6 in *G. panduratus*), but being much smaller than figured for either species (while Whitley speaks of the spines in *G. insidiator* being smaller than those in *G. panduratus*, a comparison of figures suggests the former are more massive). The longest dorsal spine, (*f*), is here the 6th. The armament of the genal stay is decidedly more obvious in the local fish than is figured for *G. insidiator*, but its spinous elements are somewhat less developed than as depicted in Richardson's figure of *G. panduratus*.

The chief points of difference reported as distinguishing *G. i. mirandus* from *G. i. insidator* are enumerated below, followed in parentheses by a specification of our fish. (*a*) scales between scapular spine and hypural joint about 40; about 30 (about 45); (*b*) nasal spines sharp, ending in knobs (not knobs, not sharp but bluntly pointed); (*c*) transverse ridges joining supraorbital ridges forming an oblique shelf overhanging occipital depression; front wall of depression vertical (as in former); (*d*) anterior spine on each side near origin of dorsal almost divided so that each has two points; not so divided (deeply divided, or, as here interpreted, representing two spines, see above); (*e*) soft dorsal base about one-quarter spinous base; about one-sixth (0.23); (*f*) pectoral equal to head, less than head (measured from front of base greater, measured from insertion of middle rays less, than head); (*g*) origin of ventral in advance of 5th dorsal spine; below 5th (below 4th); (*h*) rosy patch on operculum extending into occipital depression; not so (as for former); (*i*) more whitish blotches on the dorsal and pectoral than in *G.i. insidiator* (dorsal lacks whitish blotches altogether, but has two extensive pinkish areas; pectoral with much less white than in *G.i. insidiator*); (*j*) two large white blotches on back below spinous dorsal; absent (two small well-separate white spots here). Other differences in colour pattern between our specimen and the figured holotype of *G. i. insidiator* include: black arc across outer half of rayed dorsal in our fish a wide bar, greatest width about two-thirds an eye diameter, subequal to greatest width of black bar of anal in both fish; much less white in pectoral; no white on membrane between first and second anal spines; less extensive white patch behind scapula; much less light colour on lateral surface of postorbital head; white behind head not diffuse, but rounded, very much smaller.

The excavation of the spinous dorsal membrane is depicted as much more extensive in *G. panduratus* than in *G. insidiator*: in our fish the outline of the fin is quite different from either, the membrane extending to tip of spine and running back in a virtually straight line to front of next spine, so that the outline formed by membrane and distal free part of succeeding spine constitutes a symmetrical V, its width subequal to its depth throughout posterior two-thirds of fin, but somewhat greater between the first four or five spines.

On the evidence provided by this fish it is considered inadvisable to propose any

variation of the currently accepted classification of *Glyptauchen*: it seems apparent, however, further specimens will need to be examined and a direct comparison of adequate material with a wide geographical range will need to be undertaken before the taxonomic position becomes stabilized on a satisfactory basis. The crisscross pattern of resemblances and differences that has now become apparent certainly raises some question as to whether the distinctions drawn between the recognized species are consistently of a higher order than those drawn between their subspecies. It may well prove that the currently recognized *Glyptauchen panduratus panduratus* (Richardson, 1850) Western Australia), *G. p. deruptus* Whitley, 1931 (South Australia), *G. insidiator insidiator* Whitley, 1931 (New South Wales) and *G. i. mirandus* Whitley 1931 (Tasmania) are best regarded as four subspecies of Richardson's species.

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PRELIMINARY NOTE ON AN ABORIGINAL STONE ALIGNMENT AND ASSOCIATED FEATURES

by Jim Stockton
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(with four text-figures)

ABSTRACT

Only one substantiated Aboriginal stone alignment in Tasmania has been described. Pebble heaps adjacent to the site appear to be of Aboriginal origin. Similar pebble heaps from other coastal areas are reported.

ABORIGINAL STONE ARRANGEMENTS

The only Aboriginal stone alignment in Tasmania which has been substantiated (fig. 1) is discussed here with a survey of the site. Jones (1965a, b) briefly described the feature and excavated a small area. The excavation revealed two superimposed alignments.

The top feature, a stone alignment, was embedded in midden deposits. Buried under this alignment, was a similar alignment running roughly parallel to it.. Chronologically, the lower row of stones were placed along the crest of the dune at the time with everyday occupational debris eventually burying it. When the level of this debris reached about 0.4m above the lower stones, the top alignment of stones was then constructed (Jones 1965a). The alignment follows the ridge of an aeolian sand dune. East of the ridge is the Tasman Ocean, and, to the west, there are extensive freshwater swamps. The dunes in the immediate vicinity are stabilised with coastal heath vegetation but dunes nearby lack vegetation and have become unstable. Sheep and cattle graze in the area but the main threat to the stability of the area is rabbits.

An alignment plan (fig.2) and cross-section (fig. 4) demonstrate the relationship of the alignment to the dune and its surroundings.

Five stone features are also associated with the alignment. They were described by Jones (1965a, p. 78) as follows: "Near the northern end of the feature, and on the surface of the pebble bank, can be seen a few piles of stone, about one or two feet high. Although they could be of Aboriginal origin, the possibilities of their construction by surveyors or hunters cannot be ruled out." Figure 2 illustrates the relationship of these to the alignment. Figure 3 shows the cross-sections of these features taken on an E-W compass bearing. They include pits with raised walls, simple pits and simple cairns. On the same pebble beach 150m to the south of feature "E" several more of these features occur.

Numerous stone constructions have been noted on another pebble beach approximately 0.8 km to the south. Over thirty were noted in a distance of approximately 200m. Common features in this area were 'birdnest' shapes, pits and simple heaps of stone. The diameters of these features ranged from 800mm to 4m. One 'birdnest' shape had walls over one metre high. Large oval depressions and a cairn with an attached tail reminiscent of a tadpole were also noted in the area. The stones which make up the features generally weigh between 2 kg and 5 kg, which is the average size of the stones in the pebble beach which is obviously the source of the pebbles. Average mass of the stones in the alignment feature is considerably greater than those just

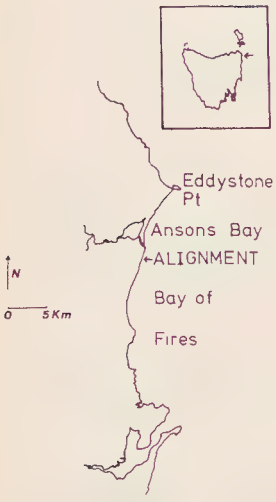

FIG. 1 - Locality map

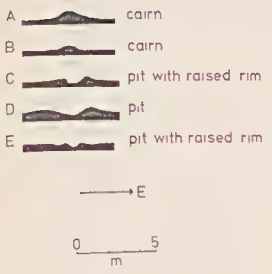

FIG. 3 - Cross-sections of cairns and pits associated with stone alignment

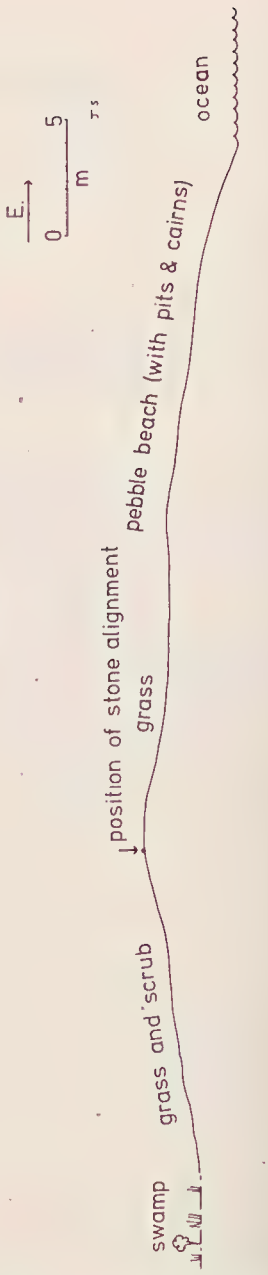

FIG. 4 - Cross-section through ridge from ocean in the east to swamp in the west

FIG. 2 - Plan of Bay of Fires stone alignment and associated features

noted. Vertical size grading or deliberate packing does not appear to be present in the stone features. The size and mass of the stone feature negates the possibility of the formation of the present configuration by natural forces. Their number, density, and lack of apparent function make it unlikely that they are of European construction.

Similar heaps of stones on raised pebble beaches were reported as being on southwest, west and northwest coasts during the first six months of the A.I.A.S. Site Recording Programme in Tasmania.

Some reference to such features has been made in the past. During Robinson's 'Friendly Mission', he passed along the West Coast near Sandown Point (now called Sundown Point) on the 8th June 1830. Noted in his diary was the fact that he "passed a heap of large pebbles. The natives had placed them in different forms, some resembling rooms, gardens and passages". (Plomley 1966, p. 170). Robinson dismissed the structures thinking that "probably it was the work of children" (ibid). These are similar, in structure and design, to the stone configurations reported in other areas. (southwest, west and northwest coasts) during the first six months of the A.I.A.S. Site Recording Programme in Tasmania. What these strange constructions were used for, and what they signified to the Tasmanians, we will probably never know.

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A TASMANIAN PAINTING SITE (?)

by Jim Stockton
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(with two text-figures and one plate)

ABSTRACT

While attempting to relocate a published Tasmanian painting site, another nearby rock shelter was found to contain painting on its walls. The new cave contains at least three hand stencils and other marks in red and yellow ochre. As the site previously published has been destroyed by the flooding of Meadowbank Dam, the new site, designated Meg's Mit rock shelter, is the only known painting site in Tasmania. The painting is described and possible hypotheses for its origin proposed. An archaeological strategy for the site is outlined.

A TASMANIAN PAINTING SITE (?)

In 1958 De Teliga and Bryden (1958, p.191) reported hands painted on the wall of a cave in the Derwent Valley to the Royal Society. This was the first report in recent times of such painting in Tasmania.

The original description was vague "Our investigations showed that in the sandstone cave there were a few rough outlines, but what they were supposed to represent we could not determine. There were, however, a number of impressions or drawings of hands, both right and left. Red ochre had been smeared across some of the sandstone and the hand traced or drawn by using what appeared to us to be marl or limestone". De Teliga and Bryden published this description of the site and this led to the eventual relocation of the cave. The site has been referred to repeatedly in the literature since that time (e.g. Lourandos 1970 p.35; Stockton 1975b). It was located but now is flooded by an artificial lake. The cave wall was examined by diving but no trace of pigment could be found on the walls.

During a search for this cave, another rock shelter with aboriginal paintings was found. This cave, called Meg's Mit rock shelter, is the only aboriginal painting site known in Tasmania.

The paintings consist of three clear but faded hands stencilled in red ochre (pl.1 and fig. 1) and several indecipherable lines in yellow (fig. 2). In other parts of the walls of the cave are red ochre marks but they are mostly irregular blobs. The hands in De Teliga and Bryden's site were similarly stencilled on the rock wall in red ochre (pers. comm. E. Bannister). Although about 300 rock shelters in the adjacent area were examined, none were found to contain recognisable paintings. However, once again, blobs of red ochre adhering to the walls were noted.

Plate 1 is a photograph of the clearest hand stencil. Figure 1 is a scale drawing of the hand stencils.

The implication of this site for Tasmanian prehistory is interesting. The hand stencils in these two sites are identical in form to those found throughout mainland Australia. Tasmania has been separated from the mainland for about 10,000 years by the rising post-glacial sea level. However, it is possible that the paintings are actually of post-European settlement origin. Aborigines from the Sydney area were brought to Tasmania in the 1830's to be used to hunt and capture the locals. Others were brought as convicts, for offences in New South Wales. Hand stencils are prolific

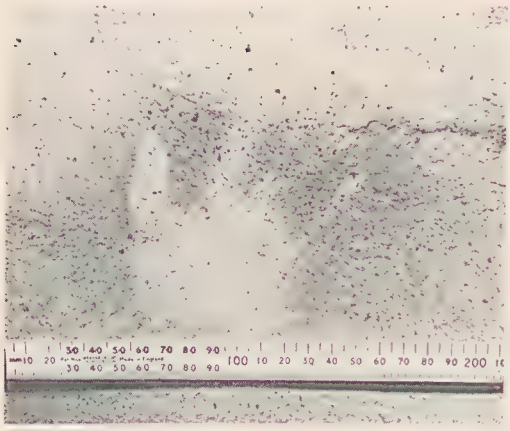

PLATE 1 - The clearest hand stencil in Meg's Mit Cave

in the Sydney and Hawkesbury regions. This sandstone shelter is very similar to those of the Hawkesbury Sandstone outcrop. Meg's Mit Rock Shelter is certainly the best accommodation available in the immediate vicinity and may have been used as a camp by visitors.

ETHNOHISTORICAL DATA

Ethnographic records of the Tasmanians at the time of contact are scarce and post-settlement accounts are often unreliable. Very little was recorded about painting in Tasmania, although considerable attention was paid to rock engraving sites.

One of the most reliable ethnographic sources are the French expeditions. Schematic signs drawn in charcoal on the inside walls of bark shelters were recorded by Péron of the Baudin expedition in 1802 on Maria Island off the south-east coast (Lourandos 1970, p. 35).

FIG. 1 - Hand stencils and ochre marks in Meg's Mit Cave, Tasmania

One of the largest descriptions of Tasmanian art work comes from one of the most unreliable sources, Bonwick (1967, p. 47):

"Our Aborigines, though an unlettered people, possessed some dim notion of the Fine Arts. As upon the sandstone of Sydney Heads are rude resemblances of fish and quadrupeds, so have marks or tokens been detected on trees and rocks in Tasmania. Mr John Batman described some he witnessed. Mr G.A. Robinson saw drawings of men and women, with some curious hieroglyphics, like the totems of tribes, when he was on the west coast in 1831. Inside the substantial huts of the Macquarie Harbour tribe were found a number of sketches of birds, beasts, and men, some of which were fairly executed. Dr Ross relates his discovery of geometrical figures, as squares and circles, on the bark in the valley of the Ouse. In the lovely vale of Belvoir, where the basaltic columns of May Hills tower over the limestone plain, a piece of bark was found, after the first two bullock drays passed that way, bearing a really good copy

of the drays, bullocks, and the men with their whips: it was better done than the markings of the cave-men of Perigord on the bones of the mammoth.

I append some rude Tasmanian sketches of men and animals with five drawings, as seen by Mr Commissary Browne on a tree, representing the sun, the moon, some snakes, and five persons in a boat."

FIG. 2 - Yellow markings, Meg's Mit Cave

Roth (1899, pp. 127-8) also deals with painting but only describes body painting. Similarly, Robinson describes aboriginal use of ochre for body painting and also describes sketches in charcoal on the inside walls of bark huts (Plomley 1966, pp. 197, 514-5, 542-3, 563, 571, 884, 917n.98). Motifs of these sketches included "circles, broad arrows and other hieroglyphical figures representing men and women, and round circles which from their different diameters I judge to have been done by a pair of scissors (Plomley 1966, pp. 514-5). Naturalistic forms were also recorded e.g. a porcupine (*ibid*, pp. 884, 917n.98).

However, nowhere in the literature is stencilling described as a technique nor are stencils found. It is not until 1958 that the first account of stencilling in Tasmania was described and even then only one site in the whole of Tasmania was known. Finding the second site does not really solve the enigma as, above the present water line, Meg's Mit rock shelter represents the most confortable camping shelter adjacent to de Teliga's cave, though more shelters may have existed below the present dam.

THE CONTACT PERIOD

The ethnohistorical period was one of outright warfare between the Aborigines and the Europeans. One of the more imaginative attempts to defeat the local inhabitants involved the importation of a group of Sydney Aborigines under the control of John Batman to help hunt and capture the local people. After some freelance operations, Batman and his Sydney Aborigines were used in a co-ordinated operation with Robinson and his local assistants. (Plomley 1966, pp. 481, 575). In October 1831 both parties moved south from Launceston with the object of capturing the Big River Tribe. The exact movements of the Sydney group, led by Cotterell, are not recorded but Robinson's party spent several weeks around Oatlands and Campbell Town. The lack of detail in Robinson's diaries about his competitors is not surprising as Batman was in effect a commercial operator. Later, Robinson does record some scandal about Batman and his treatment of his Aborigines (Plomley 1966, p. 833).

It also appears from the sketchy records that a group of Sydney natives were in the Ouse and Derwent Valleys for at least some weeks in 1831. Equally important, Robinson was in the region and, although he noted the sandstone caverns of the area, he did not mention any form of painting in them (Plomley 1966, p. 529).

Hand stencilling in the Sydney and Hawkesbury region is prolific, and examples are to be found in rock shelters which contain typical occupational debris. Stencils covered a variety of motifs and had a range of purposes in the secular and sacred contexts. Some stencils, notably of hands, appear to have been made as prosaic ornaments of habitation areas, and may well have been made in the sense of leaving a calling card. (D. Moore pers. comm.) The equivalent practice today is to write initials on the cave wall with charcoal. This has actually happened in Meg's Mit rock shelter. As a tentative hypothesis, it is proposed that Tasmanian authorship is unlikely in view of the absence of reports of stencilling in the ethnographic record and the confinement of recorded stencilling sites to two shelters which are only a few hundred metres apart. Given the presence of Sydney Aborigines in the region in the 1830s, it is important to note that Meg's Mit rock shelter offers a good camping site, and De Teliga's site is adjacent to what would then have been a small fresh water stream, which would have provided the most convenient water supply. The Derwent River at this point flowed through a deep gorge approximately 15 m below the surface of the present Meadowbank Dam.

There is one last problem to consider. There is no scale in the illustration published by De Teliga and Bryden and measurements are not included in the description. However, the discoverer and property holder, Mr. E. Bannister, recalls that the stencils were about the size of small man's hand. The hands in Meg's Mit rock shelter are quite small, particularly the single stencilled right hand to the right of the matched pair. (fig. 1 and pl. 1). This is a point worth investigating but lack of measurements or reliable comparative figures preclude its consideration here.

A PROPOSED EXCAVATION STRATEGY

An excavation strategy has been proposed by Dr Jim Allen of the Research School of Pacific Studies, Australian National University.

The mouth of the cave and the adjacent talus slope contain an area of deposit which appears to be undisturbed and is stabilized by grass and small bushes. At this site ochre was prepared for the execution of the stencils. If so, nodules of discarded ochre will be found in the deposit. Similar nodules of ochre with abraded surfaces have been found upstream near the present Cluny Dam site, approximately 10 km away. If these nodules can be located in the deposit in a datable context such as hearth or even in association with scattered isolated charcoal, it would be possible to get some indication of the approximate date at which they were discarded. Then, by an analysis of the composition of the discarded ochre nodules and the composition of the ochre on the walls, it may be possible to get some estimate of the antiquity of the art work.

A pre-contact date will be necessary before we can ascribe the painting to Tasmanian authorship with certainty. In view of the scientific importance of this site and the extent of public interest, excavation should be undertaken as soon as possible before both the painting and the deposit are destroyed.

CONCLUSION

Some of the difficulties inherent in the interpretation of an art site when reliable ethnographic data and comparative sites are lacking have been outlined. If the stencils are by Tasmanian aborigines, an interesting facet of cultural continuity lasting over some 10,000 years is demonstrated. The depletion of the Tasmanian aboriginal diet and tool kit has been documented by Jones (1966) and his proposed model for an archaeological sequence has not been contradicted. In view of the characteristics being sloughed off through time it would be interesting to find that an artistic form of only prosaic significance continued when items vital to survival were discontinued. Unless more stencilling sites are found or excavation results demonstrate a pre-contact

antiquity, the enigma of Meg's Mit rock shelter is most easily explained by a hypothesis of homesick visitors. If this is so, then the site represents an example of cultural diffusion in a period of acute culture shock and dislocation.

ACKNOWLEDGEMENTS

This field work was carried out as part of the A.I.A.S. Sites of Significance Programme. I wish to thank Bill and Meg Hamilton, Giles and Pip Chapman, Edgar Bannister, and Mrs Inglis for their assistance, and Mr W.F. Ellis for his comments on the manuscript.

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NATIONAL MUSEUM
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OF VICTORIA

PAPERS AND PROCEEDINGS OF

The Royal Society of Tasmania

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August 1978

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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA

VOLUME 112

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ROYAL SOCIETY OF TASMANIA

ANNUAL REPORT FOR THE YEAR 1977

The Council has the honour to present to members the following report on the activities of the Society during the year.

COUNCIL AND OFFICE BEARERS

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Dr W. Bryden

Honorary Auditor
Mr D.B. Churchill

Honorary Editor
Dr M.R. Banks

PRESIDENT

Sir Stanley Burbury, took the Chair, as President of the Society, at the General Meetings in May and June.

R.M. JOHNSTON MEDAL

At the General Meeting in May, the President presented the R.M. Johnston Medal to Professor S.W. Carey.

Previous recipients of the medal have been:

1923	Sir T.W. Edgeworth David	1946	Professor L.H. Martin
1925	Professor F. Wood Jones	1948	Professor F. Griffiths-Taylor
1929	Dr R.J. Tillyard	1950	Professor J.T. Wilson
1934	Professor W.J. Dakin	1957	Professor F. Walker
1937	Sir David Rivett	1959	Sir Edmund Hilary

CLIVE LORD MEDAL

At the General Meeting in October, the Clive Lord Memorial Medal was presented to Dr E.R. Guiler.

Previous recipients have been:

1936	Professor L.F. Giblin	1958	Mr P.G. Law
1939	Professor J.B. Cleland	1960	Emeritus Professor V.V. Hickman
1947	Dr H. Thompson	1966	Dr Winifred Curtis
1951	Professor J. Burke	1973	Dr W. Bryden

ANNUAL MEETING

At the Annual Meeting on 1 March, Mr K.D. Nicolls retired as Vice-President, and Mr O.W. Reid and Dr A.G. Wallace as Members of the Council. The following were elected -

Vice-President	-	Mr G.E.A. Hale
Members of Council	-	Mr S.J. Thrower
	-	Mr J.D. Thomson
Honorary Secretary	-	Mr D.R. Gregg
Honorary Treasurer	-	Dr W. Bryden
Honorary Auditor	-	Mr D.B. Churchill

At the July General Meeting, Mr K.D. Nicolls was elected to the Council to fill the casual vacancy on the Council caused by Dr Bryden's resignation as an ordinary member of Council.

INCREASE OF SUBSCRIPTIONS

At the November General Meeting it was resolved that the following subscriptions apply from the beginning of 1978:

Members receiving the Papers and Proceedings	$ 12.00 p.a.
Members not receiving the Papers and Proceedings	$ 8.00 p.a.
Associate Members	$ 5.00 p.a.
Life Members	$ 200.00

LECTURES

The following lectures were given at General Meetings during the year -

March	"Mammals and Man in the Tasmanian Ice-Age"	Dr P.F. Murray, Tasmanian Museum
April	"Biological Control of *Sirex* Wood-wasp"	Mr K.L. Taylor, CSIRO
May	"A Philosophy of the Earth and Universe"	Professor S.W. Carey
June	"Intermediate Technology and the Future of Tasmania"	Dr D.F. Smith, TCAE, Launceston
July	"The Cell's Remarkable Skin"	Dr B. Scott, University of Tasmania
August	"Opthalmic Fluorescein Angiography - diagnostic medical photography"	Mr K. Bell, Royal Hobart Hospital
September	"Aspirin: an old drug with some new tricks"	Dr L.J. McLeod, University of Tasmania

October	"Some new information on Cetacea and seals in Tasmania"	Dr E.R. Guiler University of Tasmania
	"The Library of the Royal Society of Tasmania - its nature and organisation"	Mrs D.A. Lewis, Royal Society of Tasmania
November	"Petroleum in Modern Life"	Mr A.B. Wilson

The June General Meeting was held in Launceston; the first time that a General Meeting of the Society has been held outside Hobart.

In October, a Special General Meeting was held in the Society's Library at the University of Tasmania where members were able to inspect the Library and also to hear Mrs D.A. Lewis, the Royal Society Librarian, speak about it. A group of members from the Northern Branch attended the meeting.

LIBRARY

The library continues to provide library services for members of the Society, University staff and Higher Degree students. Inquiries have also been answered from other Tasmanian libraries, from Tasmanian and interstate scholars and from one researcher in U.S.A.

In June 1977 the University of Tasmania, which has provided accommodation and part-time staff for the library since 1970, made a full-time senior librarian, Mrs D.A. Lewis, available with a view to re-organizing the library and clearing up problems which had accumulated. This work is now proceeding.

Loan procedures have been brought under stricter control and are now functioning satisfactorily.

During the year, 793 volumes were bound for us by the University Bindery.

The library has participated in inter-library loan activities, 83 requests from other institutions having been filled in the half-year ended 31 December 1977. In the same period, three requests were made to other libraries on behalf of our members and all were filled.

The exchange programme continues to be our main source of acquisition. We received 14 titles by subscription and 716 by exchange or donation. We sent out 65 copies of the 1977 issue (Vol 111) of the *Papers and Proceedings* to Australian exchange partners and 254 copies to overseas partners in 46 countries. As well, over fifty institutions have standing order subscriptions for the *Papers and Proceedings* and a few other copies have been sold on a one-year subscription basis. We also have occasional orders for single issues of back numbers.

However, sales of the Society's publications are slow and the large stocks of back numbers present a storage problem in the library, where they take up room urgently needed for library material. It is anticipated that the bulk of this stock will soon be transferred to cellar storage in the building. This will free some shelving and the position will be further improved by the removal of one of the large study tables and its replacement by additional shelving now on order.

The *Proceedings* of the 1976 Symposium "Landscape and man : the interaction between man and environment in Western Tasmania" appeared in June 1977 and this publication has been made available to the public through a commercial bookseller. The considerable stocks of *The Diaries of John Helder Wedge 1824-35* (published by the Society 1962) which were in storage unbound have now been bound and are available for sale.

A special meeting of the Society was held in the library on 18 October. Approximately fifty members and friends attended, including twelve from the Northern Branch. The librarian gave a talk on the nature and arrangement of the library's collections and the visitors inspected a display of valuable and unusual works. This exhibition remained on display in the University Library for a month and attracted widespread interest.

The University Librarian continues to be represented at meetings of the Council of the Society.

NORTHERN BRANCH

The Northern Branch of the Society based in Launceston had the following Council -

Chairman	-	Mr P.G. Webb
Vice-Chairman	-	Mr H.S. Payne
Past Chairman	-	Dr E.V.R. Ratcliff
Honorary Secretary	-	Mr T.E. Burns
Honorary Treasurer	-	Mr J.D. Abey
Members	-	Miss J.S. Gardner
	-	Mr P.S. Manchester
	-	Mr H.C.A. Pitt (who resigned during the year)
	-	Mr K.E.J. Robinson
	-	Dr D.F. Smith
	-	Mr D. Walter

Mr D. Walter was co-opted as Excursion Organiser, and Mr G.H. Stancombe member in charge of the library. Mr H.C.A. Pitt was appointed Auditor on the death of Mr J.N. Gee. Mr K.E.J. Robinson acted as relieving Treasurer.

The following lectures were given -

March	"The Geology of the Tamar Valley"	Mr P.S. Manchester
April	"Shells"	Mrs Zoe Stancombe
May	"A Philosophy of the Earth and Universe"	Professor S.W. Carey
June	"Intermediate Technology and the Future of Tasmania"	Dr D.F. Smith
July	"Mathematics - man's basic science"	Dr D. Blest
August	"China - an ancient culture : a recent perspective"	Mr H.S. Payne
September	"Astronomy - the oldest and the youngest science"	Dr R. Rogers
October	"Historic Highway"	Mr George Webb
November	"Early Horticulturists in Tasmania"	Dr D. Martin
December	Members' Night -	
	"Marble Bar and the Hammersley Range"	Mr J.W. Ikin
	"Queen Victoria's Most Unusual Funeral"	Commander E.J. Prevost
	"Long Marsh Dam"	Mr D. Walter

The four lectures from June to September were a series by staff of the Newnham Campus of the Tasmanian College of Advanced Education. The inaugural meeting of the series was a General Meeting of the Society held in association with the Northern

Branch and was chaired by Sir Stanley Burbury, as President of the Society.

Excursions visited the Tamar Valley in March and Long Marsh Dam in December.

PUBLICATIONS

Volume 111 of the Papers and Proceedings was published early in September. It contained 9 papers, totalling 189 pages, including papers on several aspects of zoology, geology and archaeology.

The proceedings of the Queenstown Symposium of November 1976, were published in August under the title 'Landscape and Man'.

The Society is indebted to Dr Banks for his continuing work as Honorary Editor. During Dr Banks' absence overseas Mr D.R. Gregg assisted with editing of the Papers and Proceedings and Dr J.B. Kirkpatrick with 'Landscape and Man'.

MEMBERSHIP

During the year the membership was 532, a decrease of 4.

The membership is made up as follows -

	Northern Branch	Total
Honorary Life Members	2	5
Life Members	10	36
Ordinary Members, receiving the Papers and Proceedings	82	280
Ordinary Members, not receiving the Papers and Proceedings	102	182
Associate Members	19	27
	215	532

COUNCIL MEETINGS

The Council met six times during the year with Mr P.S. Manchester and Mr P.G. Webb representing the Northern Branch on the Council.

NOMINEES TO OTHER BODIES

The Council re-elected Dr M.R. Banks and Dr D. Martin to the Board of Trustees of the Tasmanian Museum and Art Gallery. They report on the year's activities as follows:

> The Trustees of the Tasmanian Museum and Art Gallery welcomed the decision of the State Government to purchase the Commonwealth buildings adjacent to the Museum. If all the buildings are made available to the Trustees together with adequate funds to make full use of them, the satisfactory development of the Museum and Art Gallery on its present site near the centre of Hobart will be assured.
>
> Responsibility for the Tasmanian Herbarium has been accepted by the Trustees of the Tasmanian Museum and Art Gallery and the State Government has provided funds for the appointment of a Curator and an assistant. Dr A.E. Orchard has been appointed

Curator and should start work in March 1978. The Herbarium will continue to be housed, for the present, at the University of Tasmania.

The Minister for Education, Recreation and the Arts has set up a Museums and Art Galleries Advisory Committee under the Chairmanship of Mr K.E.J. Robinson and with the following terms of reference:

- To advise the Minister on Government policy in relation to the funding of museums and art galleries.

- To advise the Minister on grants to individual museums and art galleries.

- To advise the Minister on the rationalisation and development of museum and art gallery activities within Tasmania.

The Council re-elected Dr M.H. Hurburgh to the Board of Trustees of the Royal Botanical Gardens. He reports on the year's activities as follows -

The year saw the completion of the automatic irrigation system for the Gardens.

A general improvement to the main entrance was carried out with the construction of a rockery.

Fifteen grass plots, each sown with a different species of grass for public viewing, were established.

The glasshouses, have received further attention, in particular with the installation of a polytherm heating system in the new building.

Particular emphasis has been placed on the planting of more natives and eucalypts in their respective sections of the Gardens.

ACKNOWLEDGEMENTS

The Council is grateful for help generously given by many individuals and organisations. In particular, the lecturers, the Government of Tasmania, the University of Tasmania, the Tasmanian Museum and Art Gallery, and the Queen Victoria Museum and Art Gallery are specially thanked for their help and cooperation.

ROYAL SOCIETY OF TASMANIA

Balance Sheet as at 31 December 1977

1976			1977	1976		1977
81 208.01	Accumulated Funds		93 809.07	33.00	Cash on hand	33.00
30.00	Subscriptions in advance		94.00	1 715.18	Cash at Bank - General Account	3 267.85
	Trust Funds -			5 752.42	- Papers and Proceedings Account	337.16
1 176.61	Clive Lord Memorial Fund	1 252.87		476.61	- Clive Lord Memorial Fund	542.37
1 760.81	A.N. Lewis Memorial Fund	1 880.39		660.81	- A.N. Lewis Memorial Fund	780.39
765.98	Morton Allport Memorial Fund	814.52		860.00	Mortgage Loan	860.00
329.27	A.A. Clark Bequest	351.27			Commonwealth Treasury Bond and Inscribed Stock (at cost)	10 430.00
2 235.87	Joseph Milligan Bequest	2 361.97		10 430.00	Interest Bearing Deposits	7 000.00
1 145.74	R.M. Johnston Memorial Fund	1 223.30		7 000.00	Library (at valuation for insurance)	15 000.00
502.99	Henry Oliver Bequest	522.69		15 000.00	Publications (at selling prices)	66 758.15
1 269.77	W.H. Hudspeth Memorial Fund	1 322.17		50 300.00		
1 802.97	Life Membership Fund	1 376.67	11 105.85			
$92 228.02			$105 008.92	$92 228.02		$105 008.92

In my opinion the attached Balance Sheet, Accumulation Account and Statements of Receipts and Payments for the General Account and Papers and Proceedings, are properly drawn up so as to give a true and fair view of the state of affairs of the Royal Society of Tasmania as at 31 December 1977, according to the books and records produced to me. The asset values of the Library and Publications on hand is accepted at the valuation as stated in the Balance Sheet, having been submitted to me by the Royal Society of Tasmania.

27 February 1978

D.B. Churchill, F.A.S.A.
Licenced Auditor

ROYAL SOCIETY OF TASMANIA

GENERAL ACCOUNT TO 31 DECEMBER 1977

Receipts			Payments	
Balance brought forward		1 715.18	Stationery	228.90
Subscriptions -			Insurance	40.51
2 @ $100	200.00		Attendants' fees	332.46
248 @ $ 8	1 984.00		Library expenses	200.00
166 @ $ 5	830.00		Accounting fees	96.00
22 @ $ 3	66.00		Secretarial fees	400.00
Other years	589.00	3 669.00	Meetings	96.19
Interest		991.38	Petty Cash	120.00
Sales of publications & Papers and Proceedings		2 312.35	Management fee	1 450.00
Government Grant		1 450.00	Post box rental	102.00
Rent		224.77	Postage and freight	429.59
Symposium		4.25	Bank fees - overseas cheques	1.74
Miscellaneous		17.13	Photocopying	18.24
University subsidy		1 000.00	Papers and Proceedings Account	1 343.23
Donations		4.00	Symposium expenses	109.11
Premium on note conversion		12.00	Subscriptions	79.50
			Printing of Papers and Proceedings and publications	3 084.74
				8 132.21
			Balance carried forward	3 267.85
		$11 400.06		$11 400.06

PAPERS AND PROCEEDINGS ACCOUNT TO 31 DECEMBER 1977

Receipts		Payments	
Balance brought forward	5 752.42	Printing and binding -	
		Volume 110	2 345.60
Interest	751.59	Volume 111	4 428.80
Transfer from General Account	1 343.23	Equipment - projector	703.40
		Telephone and sundry expenses	32.28
			7 510.08
		Balance carried forward	337.16
	$7 847.24		$7 847.24

Papers and Proceedings of the Royal Society of Tasmania, Volume 112, 1978.

(ms. received 28.10.1977)

NEW SPECIES IN THE FAMILY EPACRIDACEAE

by S.J. Jarman and R.K. Crowden
Department of Botany, University of Tasmania

ABSTRACT

Three Tasmanian endemic species from the Epacridaceae are considered. Specific status has been given to *Monotoca scoparia* var. *submutica* and a new variety, *Monotoca submutica* var. *autumnalis*, is described. In addition, descriptions for two recently discovered species, *Cyathodes pendulosa* and *Epacris navicularis*, are included.

DESCRIPTIONS

Monotoca submutica (Benth.) S.J. Jarman, comb. et stat. nov.

BASIONYM: *Monotoca scoparia* R. Br. var. *submutica* Benth., Fl. Austral. 4 : 231.
HOLOTYPE: Mt. La Perouse, Tasmania, C. Stuart, 1868 (K).

An erect, compact shrub, 1 - 3 m high, or sometimes a small tree up to 6 m high, branchlets puberulent, plants usually dioecious. Leaves suberect, elliptical to oblong or obovate, 6 - 12 mm long, 2 - 3.5 mm wide, flat or slightly convex with the margin scarcely recurved, upper surface green, lower surface glaucous, apex obtuse with a short callous point, petiole distinct, c. 1 - 1.5 mm long. Flowers axillary, often solitary but also in short spikes of 2 - 4 flowers, pedicel usually recurved with a variable number of bracts (2 - 7). Sepals broadly ovate, c. 1 mm long, ciliate. Corolla white but quickly turning yellow-white when removed from the plant, tube c. 1 mm long, equal in length to the calyx, lobes longer than the tube. Anthers half exserted on male flowers, absent on female flowers. Ovary unilocular. Disk of 5 lobes. Drupe spherical or oval, orange or yellow, 2 - 4 mm deep.

Flowering time: September - October.

Distribution and Habitat: Endemic to Tasmania. *M. submutica* is widespread in southern and western Tasmania, growing in subalpine forests, where it is usually a low to medium shrub, or in wet sclerophyll associated with rainforests where it forms a small tree. A more robust form than typical *M. submutica* is known from Freycinet Peninsula on the east coast.

Comments: *Monotoca submutica* differs from *M. scoparia* in habitat, habit, flowering time (excepting var. *autumnalis*), leaf shape and size, and in having corolla lobes longer than the tube.

Monotoca submutica (Benth.) S.J. Jarman var. *autumnalis* S.J. Jarman, var. nov.

Frutex humilis laxus 15 - 40 cm altus. Folia patentia late ovata - late elliptica, lamina 3 - 6 mm longa 2 - 4 mm lata.

HOLOTYPE: L. Nicholls, Mt. Field, Tasmania, R.K. Crowden and S.J. Jarman, 7.3.73 (Tasmanian State Herbarium, HO).

A low open shrub, 15 - 40 cm high. Leaves spreading, broadly ovate to broadly elliptical, lamina 3 - 6 mm long, 2 - 4 mm wide.

Flowering time: February - April.

Distribution and Habitat: At present, this species is known only from subalpine forest on Mt. Field where it forms part of the low shrubbery beneath *Eucalyptus coccifera* and *E. johnstonii*. It is known from the L. Webster track and from around L. Nicholls and Beattie's Tarn.

Comments: A distinct separation in flowering and fruiting times occurs between this variety and typical *Monotoca submutica*. Other differences between the two are mostly a matter of degree, but these have a cumulative effect so that no difficulty is experienced in recognising the two taxa in the field.

Cyathodes pendulosa S.J. Jarman, sp. nov.

Frutex humilis erectus 0.5 - 1 m altus similis habitu *Cyathodi divaricati* secus caulem fasciculatum, ramulis pubescentes, plantae plerumque dioeciae. Folia alterna et laxa in caulibus primariis autem conferta et saepe petiolis tortis aspectu disticho in caulibus brevibus lateralibus, 3 - 8 mm longa, 0.5 - 1.5 mm lata, lamina reflexa vel patens convexa, margo scaberulus, apex protractus in acumen tene pungens, supra viridia subtus glauca et striata venis 3 - 5 inramulis parallelis; petiolus brevis circa 1 mm longus. Flores solitaris terminales raro axillaris penduli, pedicellus 2 - 4 mm longus. Bractae ciliatae imbricatae bracta suprema longitudine ½ calycem aequans. Sepalia c. 2 mm longa elliptica apice rotundato. Corolla alba glabra 3 - 4 mm longa, lobi tubo breviores. Antherae semi-inclusae. Discus 5-lobus vel e squamis 5. Ovarium 5-loculare. Fructus drupaceus 5 - 9 mm profundus 7 - 12 mm in diametro ruber vel roseus.

HOLOTYPE: Foothills of Ben Lomond, Tasmania, R.K. Crowden and S.J. Jarman, 16.6.1976 (Tasmanian State Herbarium, HO).

A small erect shrub, 0.5 - 1 m high, resembling *C. divaricata* in habit, with branches clustered along the stem, the branchlets pubescent, plants usually dioecious. Leaves alternate and loose on primary stems but crowded and often with the petioles twisted, appearing distichous, on short lateral branches, blade reflexed or spreading, entire, convex, the margin minutely scabrous, 3 - 8 mm long, 0.5 - 1.5 mm wide, apex tapering to a fine pungent point, upper surface green, lower surface glaucous and striate with 3 - 5 parallel unbranched veins, petiole c. 1 mm long. Flowers solitary, terminal, rarely axillary, nodding, pedicels 2 - 4 mm long. Bracts imbricate, ciliolate, the uppermost c. half the length of the calyx. Sepals elliptical with rounded apex, c. 2 mm long, ciliolate. Corolla white, glabrous, 3 - 4 mm long, lobes shorter than the tube. Anthers half exserted. Disk of 5 scales or lobes. Ovary 5-locular. Fruit a drupe, 0.5 - 0.9 mm deep, 0.7 - 12 mm in diameter, pink or red.

Flowering time: May - July

Distribution and Habitat: Endemic to Tasmania. *C. pendulosa* was collected from the south-eastern foothills of Ben Lomond (N.E. Tasmania) where it grows among rocks and boulders in open Eucalypt forest (*Eucalyptus delagatensis*). Accompanying Epacrid species include *Cyathodes parvifolia* and *C. glauca*. The range of its distribution in Tasmania has not been fully determined but it is known from at least three other locations in the north-east, i.e. St. Patricks Head, the L. Leake Road and near Mt. Puzzler.

Comments: *C. pendulosa* appears closest to *C. divaricata* and *C. parvifolia* but it differs from both in a number of characters. It resembles *C. divaricata* in habit, forming an open shrub with short branches in annual clusters along the stems. The leaves are small and closely resemble those of *C. parvifolia*. The flowers are white with glabrous lobes similar to *C. parvifolia* but are larger attaining the size and shape of *C. divaricata* flowers. The fruit shape and size are similar to those of *C. divaricata*.

C. pendulosa was first brought to our attention by Mr. R. Shepherd (Department of Lands, Hobart).

Epacris navicularis S.J. Jarman, sp. nov.

Frutex humilis ramosissimus ad 0.5 m altus, caules nouvelli pubescentes, caules veteres scabri cicatricibus procumbentibus foliorum. Folia conferta imbricata quinquefaria navicularia 2.5 - 3.5 mm longa circa 1 mm lata crassa concava, subtus carinata, apex acutus vel acuminatus acumine brevi incurvo, margo ciliolatus; petiolus brevis latus. Flores solitari ad apicem ramorum axillares subsessiles. Bracteae et sepalia late lanceolata ad ovata-elliptica acuta vel acuminata ciliolata; sepalia circa 3 - 3.5 mm longa. Corolla alba campanulata, tubus lobis et calyce breviores. Stamina filamentis antheris fere aequilongibus. Discus e squamis 5. Ovarium 5-loculare, ovuliis multis, stylus tubo aequilongus.

HOLOTYPE: Mt. Sprent, Tasmania, R.K. Crowden, J.A. Hills and S.J. Jarman, 8.2.1977 (Tasmanian State Herbarium, HO).

A small much branched shrub up to 0.5 m in height, young stems pubescent, old stems rough with raised leaf scars. Leaves crowded, imbricate, in 5 ranks, ovate-elliptical, 2.5 - 3.5 mm long, c. 1 mm wide, thick, concave, the lower surface keeled, apex acute or acuminate with a short incurved point, margin ciliolate; petiole short, broad. Flowers solitary, axillary at the tips of the branches forming short terminal heads. Bracts and sepals broadly lanceolate to ovate elliptical, acute or acuminate, ciliolate, sepals 3 - 3.5 mm long. Corolla white, campanulate, the tube shorter than the lobes and the calyx. Stamens with filaments as long as the anthers. Disk of 5 broad scales. Ovary 5-locular, with numerous ovules; style as long as the tube.

Flowering time: January - March.

Distribution and Habitat: Endemic to Tasmania and known only from Mt. Sprent on the Wilmot Range, south-west Tasmania (c. 1040 m alt.). It occurs in exposed alpine heathlands.

Comments: Closest affinities are with *Epacris petrophila* from which *E. navicularis* differs in leaf shape, the persistence of crowded raised leaf scars and the presence of longer sepals and style.

It may be separated from all *Epacris* species by the 5-ranked arrangement of the leaves.

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A PHILOSOPHY OF THE EARTH AND UNIVERSE

The Robert Mackenzie Johnston Lecture
to the Royal Society of Tasmania
May 2nd, 1977

by S. Warren Carey

ABSTRACT

The universal null emerges with simplicity as an inevitable consequence of many physical phenomena and principles.

RETROSPECT

My first address to this Society was thirty-two years ago in this hall, on Tasmania's place in the geological structure of the world. What I said then was contrary to the beliefs of the overwhelming majority of the geologists of the time. Today it is the commonly accepted dogma throughout the world. But during the intervening decades I have added to that concept of continental dispersion the still more radical proposition of accelerating expansion of the earth. So once again I am the odd man out.

Like Kipling's cat that walked by itself, the way of the loner is much harsher than the smoothed path of those who walk in the mutual admiration society of the orthodox. Bondi (1960 p.6) has pointed out that whereas we should seek economy of hypotheses, there is nevertheless a widespread tendency not to count assumptions implicit in the currently accepted doctrines, and so to excise with Occam's razor a new alternative which involves no more assumptions than the popular concept. Unfortunately, scientists being human, much more severe demands and ill-founded rebuttals, even slurs *ad hominem*, are approvingly thrown at the unorthodox loner.

Disheartening as it has been to have one's best work rejected by the academies on such grounds, nevertheless, the painful process has in the long run been beneficial, like the torturous forging and tempering of steel. For throughout the decades I have been forced to dig deeper and deeper into fundamental assumptions and "axioms", first of geology, then of all science, to the ultimate source. From this quest has slowly emerged a new philosophy of the universe, which is the subject of my address to-night.

Before delving into this ultimate subject, first I should tell you briefly why I am convinced that the earth is expanding, when so many of my colleagues think differently. For it was my need to explain the dispersion of the continents which led me to earth expansion, and my need to explain earth expansion, and that ancient rocks did not demand substantially greater gravity acceleration, which forced me to examine the assumptions of cosmology, and thence, the origin of the universe.

THE EXPANDING EARTH

The majority of all geologists and geophysicists now agree that all continents have separated from each other and that the existing floors of all oceans have developed during the last twentieth of the earth's life. Most geologists assume that the radius of the earth is virtually constant, and therefore that, as new ocean floors have developed between the continents, so equal areas of ocean floors have been swallowed and removed. The ocean trenches which girdle the Pacific have been identified as the sites of crustal consumption.

Up to a quarter of a century ago, I too made these assumptions; until it became increasingly clear that this explanation led to fatal paradoxes when applied to the whole earth, and that earth expansion at an accelerating rate was inescapable.

In general, all evidence indicating dispersion of the continents and growth of new oceanic crust is satisfied equally by the constant-radius and earth-expansion models. But several other major facts, which I have set out more fully elsewhere (Carey 1976), deny the constant-radius model and imply large expansion:

(1) Palaeomagnetic and palaeontological data agree that North America is more than 30° nearer the north pole than it was in the Permian Period. Likewise Europe is some 40° further north, and Siberia about 17° further north. Hence all continents have converged on the Arctic by large amounts since the Permian. Yet the Arctic has been a region of extension since that time, with no subduction between these converging blocks. This is impossible except on an expanding earth. Data from the Triassic, Jurassic, and Cretaceous Periods all independently give the same conclusion, but in progressively diminishing degree, indicating that the expansion has been continuous.

(2) Palaeomagnetic poles plotted from individual regions overshoot their mean pole by increasing amounts with increasing age back into the Tertiary, which implies that a degree of arc corresponded to progressively less kilometres in earlier times. Earth expansion would produce this result.

(3) The Pacific Ocean is roughly circular and significantly less than a hemisphere. All agree that all the other oceans--Arctic, Atlantic, Indian, and the marginal seas of the Pacific--have developed since the Palaeozoic by separation of adjacent continents. Hence the modern Pacific must be only half its Palaeozoic size.

But each of the continents around the Pacific perimeter have separated from each other by large amounts during the dispersion of Pangaea. Hence we have the paradox of the Pacific Ocean reducing to half its size while its perimeter is substantially increasing. This is only possible on an expanding earth.

(4) All reconstructions of Palaeozoic Pangaea show a gap tapering from the perimeter inwards. The most commonly favoured reconstruction shows this gap between Australia and southeast Asia, diminishing westwards along the Tethys to near zero in the western Mediterranean. Yet palaeogeography right through the Palaeozoic requires a close connection down the east coast of Asia to Australia and New Zealand. This paradox results from the assumption of a constant-radius earth, and evaporates on a reconstruction with smaller radius.

Likewise India has close palaeogeographic ties with Australia, Antarctica, Madagascar, East Africa, Arabia, and also with Persia and Afghanistan. Authors variously hold some of these, and sacrifice the others. All cannot be satisfied concurrently except on an expanding earth. Similarly palaeogeography requires Malaysia to have been closely tied to Gondwanaland, yet McElhinny, Haile and Crawford (1974) conclude from their palaeomagnetic data that Malaysia could not have been part of Gondwanaland. What they should have concluded is that Malaysia could not have been part of Gondwanaland if the present earth radius be assumed for the past.

(5) The subduction model requires both Africa and Antarctica to have swallowed within continental Africa and continental Antarctica respectively an area of ocean floor equal to the area of these continents, and these subduction zones are required to be currently active. Such subduction zones do not exist. The plate-subduction model cannot be applied globally.

(6) According to North American data the Triassic equator passed through Texas

and Florida. But according to South American data the Triassic equator passed through northern Colombia and Venezuela. The constant-radius model requires subduction and crustal elimination latitudinally through the Greater Antilles. This would result in missing palaeolatitudes between North and South America. The fact is that palaeolatitudes are duplicated, which is what is required by earth expansion. The same double-equator paradox occurs between Africa and Europe, and between Australia and Asia.

These and several other facts led me a quarter of a century ago to progress from the dispersion-subduction model to the dispersion-expansion model.

Critics demanded of me a physical explanation of the cause of such gross expansion before they would take it seriously, even though their own model lacked adequate physical base. Many causes have been suggested to explain expansion. Paramorphic phase changes in the deep interior during the accelerating outgassing of the earth goes part of the way, and so does the progressive decline of the gravitational constant (as deduced by Dirac on philosophical grounds, van Flandern from the recession of the moon, Brans-Dicke-Jordan from their mathematical models, and Hoyle-and-Narlikar and Wesson from cosmogony). All this led me back to the most fundamental enigma of all, that had troubled me throughout my life--the origin and evolution of the universe itself.

THE ENIGMATIC UNIVERSE

Since the dawn of pre-history everyone who has contemplated the stars has wondered how, whence, when, why, and whither? Most have shunted the problem into the too-hard basket. Their savants, denied such escape, invoked multiple gods, single gods, or pantheism. Most assumed a special initial state - the Egyptian egg, the Hindu tortoise bearing the elephants which supported the world, the Polynesian air god Tangaloa, or the pregnant chaos of Milton. Gods of two kinds emerged: the meddling god of the Zoroastrians and of Plato, who interferes as and when he chooses, and the aloof god (as of Descartes) who created matter and motion, then left the universe to develop independently from this seed. Democritus of the fifth century B.C. was the first on record to conceive a self-created universe from the random concurrence of atoms (-- but whence his atoms?). Thence to the modern Russian materialists who dismissed all theology as superstition we should have outgrown.

But the fundamental enigma of the origin and destiny of the universe remained. Who is competent to attempt to answer? A cosmologist? Astrophysicist? Mathematician? Biologist? Theologian? Perhaps even a geologist? Alexis Carroll in his *Man the Unknown* wrote that to an anatomist, man is a system of bones and muscles, to a physiologist he is a sack of organs, to a biochemist an interplay of enzymes and chemical complexes, to a psychologist a mind, and to a priest, a soul. Man is all of these, and more. Each sees but an abstraction from the reality. So with the universe. Each of us filters it through our own slit, and each of us is part of it, short-spanned in space and time. We may each offer our bit to the conception of the seemingly infinite whole, and each of us must shield each other from the naïvete of our narrow vision.

As a high school boy I used to wonder why was the sky black, when if the universe was infinite every line should eventually meet a star; and why did everything in the universe rotate? I was also puzzled about the claim that both momentum and energy had to be conserved. Truly, one was a vector and the other a scalar, and one essentially dynamics and the other essentially statics; but one had the form mv and the other mv^2, so that, notwithstanding that sufficient independent equations could resolve such difficulties, I suspected that conditions might arise where one conservation law had to yield. It seemed clear that in such circumstances the momentum law was the more fundamental; for whereas energy may transform into many modes (mechanical, thermal,

electrical, elastic, magnetic, electromagnetic, and even into matter), momentum has no transformations, and momentum must be conserved as momentum still. Perhaps this was a clue to a fundamental truth of the universe--that the sum of the energy and the sum of the momentum of the universe are each zero. For at zero differing exponents become irrelevant.

Milne's Dimensionless Hypothesis

Another clue pointing in the same direction was Milne's dimensionless hypothesis (see Walker, 1936, p.121) which held that cosmological theory should have no constants with dimensions. If accepted, this seemed to imply that all physical dimensions (M, L, T,) should mutually cancel at the beginning, *and at all subsequent times.*

The Ultra Embryo

Hubble's demonstration that nebulae were receding with velocities which increased the further they were from us implied (to quote Dirac, 1937) that "the universe had a beginning about $2x10^9$ years ago when all the spiral nebulae were shot out from a small region of space, or perhaps from a point." What a massive point! I found this ultra-heavy egg indigestible. Black holes, so dense that even radiation cannot escape, would be light-weight thistledown compared with this initial embryo. Lemaître (1951) called it the primeval atom. Gamow (1952) called it *ylem* and exploded it with his initial "big bang". But surely nothing could escape such a mass concentration. This enigma again trailed the clue. Namely that matter had grown as it spread, and the regression *Denken-Experiment* should have included diminishing mass, so that the initial concentration, far from the stupendous mass contemplated by Hubble and Gamow, had negligible mass, or *no mass at all.*

Conservation of matter

Such heresy clashed with the law of conservation of matter. However, on this question, Ernst Mach wrote (1893): "Investigators have had another struggle on their hands, and by no means an easy one, the struggle with their own preconceived ideas, especially with the idea that philosophy and science must be founded on theology". And "notions of the constancy of the quantity of matter, of the indestructibility of work or energy, conceptions which completely dominate modern physics, all arose under the influence of theological ideas". (See also Gregory, 1969, p.149). Science has not grown from orderly development of fundamentals, but from random empiricisms seen through the constraining filters of our creeds.

Creation

Creation, and the ultimate origin and destiny of the universe, was also a perennial problem. Postulation of a creator did no more than start the chicken-and-egg infinite series of creators to create creators, or if not an infinite series, the first term would have to be Aristotle's imaginary uncaused cause, unique and different in concept from all the terms which followed.

Here again there was an obvious clue. For just as in the algebra of complex numbers the real terms and the imaginary terms can be segregated as separate complete statements, so with complex propositions involving both material and spiritual these immiscibles should yield segregated propositions each complete in themselves. This could only mean that the sum of the material could only be zero before and after postulated metaphysical excitation.

However, theology aside, all theories of cosmology require creation, even though creation of matter is contrary to physics' own conservation laws. Bondi (1960, p.9) has crystallized three classes of answer concerning the 'beginning' of the universe: (a) "The 'beginning' is a singular point on the border of the realm of physical science. Any question which refers to antecedents of the beginning or the nature of the beginning [e.g. creation] can no longer be answered by physics and is not a proper

question for it." The laws of physics come into being with creation but do not explain creation. Here physics begs the question of creation by sweeping it under the mat. As McCrea (1964) puts it, creation happened once and for all, and therefore is not subject to ordinary scientific discussion, but determines the initial conditions for the rest of the discussion.

(b) "There was no 'beginning'. The universe on the large scale is either unchanging or possibly going through cyclical changes, but is of infinite age". Steady-state theories and the 'perfect' cosmological principle belong to this category. Creation is continuous but not explained by physics. The 'arrow of time' has no place. Initial conditions cannot be discussed because the universe always existed, essentially as it is now.

(c) "The 'beginning' was a particularly simple state, the simplest, the most harmonious and most permanent we can imagine. It contained within itself, though, the seeds of growth and evolution, which at some indefinite moment started off a chain of complicated processes which by now have changed this to our present universe". The laws of physics are universal and have no exclusions nor exceptions whatever. My own philosophy, which I will present to you to-night belongs to this third category, but includes continuous creation compatible with the laws of physics. The beginning is indeed the simplest and most harmonious conceivable--a universal null, a cypher, which integrates the cosmos with the infra-nucleon.

UNIVERSAL NULL

Thus several lines of thought led me to the same answer, that the sum total of the universe is zero. That the sum of all matter and energy of the universe is zero, that the sum of all momentum in the universe is zero, and that the sum of all charge in the universe is zero--a universal null! In such a model all the conservation laws are maintained--at zero. Entropy and temperature mutually cancel at absolute zero as required by the Nernst theorem. Differing exponents are irrelevant, at zero. The universal null model predicts Dirac's large-number equivalences, and solves the problem of creation (because nothing is really created), and of Olber's paradox; it accounts for the gross thermodynamic disequilibrium of the universe and its waxing entropy and mean temperature, and gives meaning to the arrow of time.

Momentum

A single particle in a universal void has neither velocity nor momentum. Once there are two particles, each has velocity and momentum relative to the other. The momentum of the one cancels that of the other. The sum of all momentum of the universe is, I suggest, zero.

Mass-energy

According to Mach's principle a single particle in a void has zero inertial mass. Infinitesimal force accelerates it. Energy is zero because inertial mass is zero so that potential energy mgh and kinetic energy $\frac{1}{2}mv^2$ are each zero. Inertial mass is the effect of all matter in the universe. Einstein also emphasized that a single particle in a void could not have inertia for there can be no inertia of matter against space, only inertia of matter against matter. Energy is a direct first power function of inertial mass. The primitive form is mgh, which may convert to any of the other energy modes. Universal potential energy (and from this the derivative energy modes) is directly proportional to total inertial mass of the universe. As mass has grown from the initial null, so has energy, *pari passu*.

Møller (1958) has formulated a consistent expression for the total energy density of the universe consisting of a matter part and a gravitational part. When this expression for the energy density is applied to the case of the metric for a homogeneous

and isotropic universe, "the energy density is zero everywhere and at all times. This means that the positive matter energy is constantly counterbalanced by a corresponding amount of negative gravitational energy."

Energy and mass are obverse and reverse of the same coin, we could call them positive and negative, and write $E = -mc^2$, but this would be no more nor less correct than our convention of positive and negative charges, or writing positive and negative for N and S poles, left and right, or for clockwise and anticlockwise spins. Just as Mach and Einstein have the potential energy of the entire universe as the *direct cause* of inertial mass, so the kinetic energy of temperature and radiation would be the direct cause of relativistic mass. No-one really knows what mass, charge, polarity, spin, strangeness are; we simply apply these terms to describe phenomena. All such phenomena occur as *gemini*, universal twins, which appear together, and mutually cancel each other in the totality of the universe. What is matter? Schatzman (1958) has pointed out that the premise of quantum mechanics is that all elementary particles which make up matter (leptons, mesons, hyperons) transform into each other, and hence are but different aspects of the same concept. In the etherial times, it was easy to conceive them as strains in the ether, but since the ether has evaporated to a void, we are left with the particles and the strain energy gemini, which mutually cancel to zero.

Dirac's large numbers

The universal null model not only predicts, but requires the coincidences of the very large dimensionless numbers of physics and cosmology, first recognized by Dirac (1937), and is the only cosmological theory yet to do so. Dirac wrote: "Any two very large dimensionless numbers occurring in Nature are connected by a simple mathematical relation, in which the coefficients are of the order of magnitude unity." Dimensionless numbers come only from comparing paired parameters, for example a mass to a mass, an energy to an energy, a force to a force, a potential to a potential. The table shows some of Dirac's pure numbers from combination of physical constants

Dirac Dimensionless Numbers

e = electronic charge	$\frac{\text{force}}{\text{force}}$	$\frac{e^2}{\gamma m_p m_e} = 0.23 \times 10^{40}$
m_e = mass of electron		
m_p = mass of proton	$\frac{\text{length}}{\text{length}}$	$\frac{cT}{\left(\frac{e^2}{m_e c^2}\right)} \doteq 4 \times 10^{40}$
γ = constant of gravitation		
c = velocity of light		
ρ_o = mean density of matter in the universe	$\frac{\text{mass}}{\text{mass}}$	$\frac{\rho_o c^3 T^3}{m_p} \doteq 10^{80} = [10^{40}]^2$
T = reciprocal of Hubble's constant	$\frac{\text{energy}}{\text{energy}}$	$\gamma \rho_o T^2 \doteq 1$

of cosmic and microphysics (see Bondi 1960, p.60). The first is the ratio of the electrical to gravitational force between an electron and proton. The second is the ratio of the notional "radius" of the universe to the "effective" radius of an electron. The third is the ratio of the mass of the universe to the mass of a proton (which is approximately the number of atoms in the universe if it were all hydrogen). It is incredible that the concurrence of these and several other large numbers at 10^0, 10^{40}, 10^{80}, should be chance coincidence. It is even more astonishing that the fourth line (which in fact divides the third line by the product of the first two lines, and hence combines all the fundamental units listed) should come out at unity. For this is the ratio of the rest energy of any particle to the potential energy of the rest of the

universe in its field:

$$\text{Potential energy of universe in field of } m = \frac{m\gamma \times \text{mass of universe}}{\text{radius of universe}}$$

$$\sim \frac{m\gamma\, \rho_0 c^3 T^3}{cT}$$

$$\sim mc^2\, \gamma\rho_0 T_2$$

$$\text{Inertial energy of } m = mc^2$$

Bondi *(loc. cit.)* commented: "The likelihood of coincidences between numbers of the order of 10^{40} arising for no reason is so small that it is difficult to resist the conclusion that they represent the expression of a relation between the cosmos and microphysics, a relation which is not understood." But in the null universe the relation is crystal clear, and inevitable. For each new nucleon "created" adds its moity to the universal potential energy, and hence the inertial mass must equal the potential energy of the universe.

The Beginning

In this simple system, commencing from a universal null, infinitely small perturbations yield small amounts of matter, infinitely dispersed, balanced by infinitely small amounts of potential energy. The matter-energy sum remains zero, however large or however small the total dispersed mass or the total compensating potential energy, or however much transformation may occur in the form of energy. By analogy, we may compare the gravity-wave perturbation of a placid pond, or, in the business world, the creation of colossal operating credits and assets offset by compensating debits, which together feed enormous industrial activity--with no initial capital beyond a book entry, and a current totality of zero on liquidation.

Indeed, if one conceives a universal void - null time, null matter, null space, should nothing ever happen? Should there not be a random walk between the possible states of zero? Ultimately miniscule random perturbations should set off the compensating plus and minus, up and down, positive and negative, matter and potential, temperature and entropy, so that in due course a universe as we observe it would be the inevitable ultimate result. Even starting from such a universal void, if something could happen, sooner or later it will happen. Entropy of a universal void is zero. Disorder and increasing entropy should inevitably result from the Clausius law that entropy tends towards the maximum.

In this model, the universe develops into a state of perpetual motion which we intuitively exclude from our philosophy. But a *virtual* perpetual motion is possible for the universe as a *whole*, for motion itself is part of the definition, and its perpetual sum remains zero. Likewise energy to run it cancels for it only exists in counterpoint to inertial mass. Normal logic fails in propositions which deal with the validity of their own selves.

Gribbin (1976) has criticised the oscillating universe model of Landsberg and Park (1975), in which successive cycles expand to bigger and bigger radii, by pointing out that running the calculation backwards would regress the oscillation to an "infinitesimal hiccup some large number of cycles ago" -- in other words, this model also emerges from a universal null. Dirac's initial embryo, Lemaître's primeval atom, Gamow's ylem, and Gribbin's infinitesmal hiccup were all initial nullities!

Entropy

The entropy and temperature of the null initial condition should be zero, so that any subsequent condition of the universe would involve increase of entropy, and of mean

temperature. Statistically we could write $S = kT$ (entropy S, Boltzman's constant k, T absolute temperature) so that entropy is the geminus of thermal energy. As the mean temperature of the universe rises so does entropy to a theoretical maximum at the so-called "heat death" of the universe. Oscillating universe theories meet a paradox with respect to entropy. Le Maître (1958, p.9) has pointed out that "the fact that this expansion is made of matter which has already been used would result in its distribution being in a state of maximum entropy". Hence in the new phoenix universe entropy must run backwards -- unless entropy is limited in its field of validity.

Site of matter-energy creation

Many cosmogony models postulate the continuous creation of matter in the depths of space between the galaxies (e.g. Bondi and Gold, 1948, and Hoyle, 1948), either as hydrogen atoms, or as whole stars, or even as embryo galaxies (Stothers, 1966). Stothers proposes matter is created (as quasars) *where* it is lacking *because* it is lacking. McCrea, on the other hand, has proposed (1964) the continual creation of matter as a property of existing matter, and hence predominantly in the nuclei of galaxies. Dirac (1974) debates the relative merits of "multiplicative creation" with matter entering the universe where it is already most concentrated corresponding to Einstein's cylindrical closed universe, and "additive creation" which would satisfy Stother's model where the matter appears in the most tenuous space. The latter corresponds to flat Minowski space originating with the "big bang". In this argument I agree with McCrea and deny Stothers because of the relative energy demands of the two propositions.

To inject one particle in the remote depths of intergalactic space requires a birth endowment for that particle equal to the total potential energy to fall to the centre of mass of the nearest galaxy. Energy endowment to inject a particle at the galactic centre of mass is virtually zero (not quite zero because every other particle receives a trivial increment in its potential energy to fall thither). In a mature universe, most matter would enter at the centres of nebulae - as indeed Jeans deduced empirically (1928): "The type of conjecture which presents itself somewhat consistently, is that the centres of nebulae are of the nature of singular points at which matter is poured into our universe from some other and entirely extraneous spatial dimension, so that to a denizen of our universe they appear as points at which matter is being continuously created." What is this extraneous spatial dimension? Energy of course, the *geminus* of mass, the potential energy of the universe. To extend Jeans and McCrea further, it would seem plausible that all matter grows at a rate which is a power function of its own concentration.

Bondi (1960) suggested that the mean density of intergalactic hydrogen could be as high as 10^{-25} g/cm^3 or 10^5 times the mean density of the galaxies if their matter was uniformly dispersed through space (10^{-30} g/cm^3). In Bondi's model by far the predominant part of all matter is in the depths of space. There is a sharp contrast between the Jeans-McCrea model of a nebula (which I support) and the Bondi-Stothers model; in ours matter enters at the centres of nebulae and disperses outwards to the limits of the nebula; in theirs the matter enters in the depths of space and condenses into the nebulae. The problem of angular momentum distribution seems to deny this latter proposition, a problem which evaporates in the Jeans-McCrea model. Thus both the potential energy endowment and the angular momentum distribution indicate creation of matter where it is concentrated, not where it is absent. Furthermore *contracting* galaxies in an *expanding* universe lack philosophical elegance. In our model, everything expands, Earth, the Earth-Moon system, the Solar system, the galaxies, the whole universe, and what is astonishingly relevant, the Hubble constant measures each of these independent expansions, as McDougall and his co-authors pointed out (1963).

Cosmic Repulsion

All of Newton's empirical laws - of universal gravitation, of accelerated motion,

of viscous flow, and Hooke's empirical law of the proportionality of stress and strain, are probably invalid if pursued far beyond the range of the empiricism. The relativistic mass of kinetic energy is always present even at low velocities, but is much below the threshold of experimental detection, although this term dominates at speeds approaching the velocity of light. Viscous and plastic terms are always present during the elasticity experiments but are too small to be detected in short duration experiments with the materials used, although they dominate when experiments are sustained for times far exceeding the Maxwell relaxation time. So-called non-Newtonian flow is present in all viscous experiments, but in low viscosity fluids is below the threshold of measurement. However, the distinction between fluids with Newtonian viscosity and other substances regarded as non-Newtonian is solely a matter of scale and refinements of the measurements.

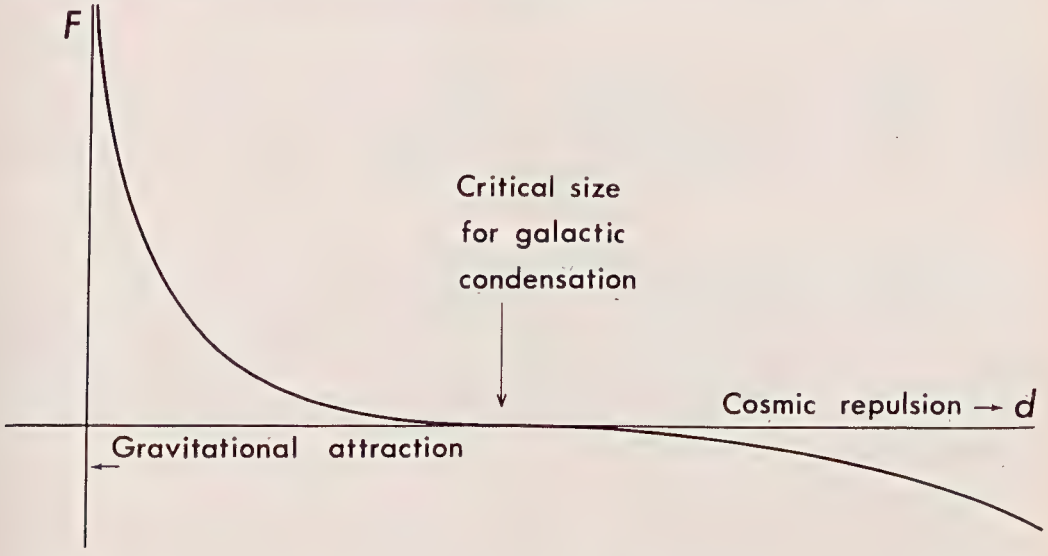
Likewise I doubt whether Newton's law of Universal gravitation

$$F = G \frac{m_1 m_2}{d^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

is valid for cosmic distances, and I suggest that an additional term is always present even though too small to be detected in less than cosmic scale. Such a term might take a form like:

$$F = G\, m_1 m_2 \left(\frac{1}{d^2} - \frac{\alpha d^2 H^4}{c^4} \right) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where H is Hubble's constant and c the velocity of light and α is a scaling constant. H/c is a very small quantity approaching zero, so for small (e.g. local and astronomic) values of d this relation reverts to Newton's law of gravitation for all practical purposes, but for cosmic values of d, $1/d^2$ approaches zero and the second term becomes significant but negative, replacing gravitational attraction by cosmic repulsion. A graph of F against d would have a form such as:



If Newton's law of gravitation (as expressed by (1) above) applied universally, the whole universe should have collapsed under gravity. If however the law took some form like (2) above then gravitational condensation would occur up to inter-galactic distances, but at cosmic distances repulsion would supersede.

A Philosophy of the Earth and Universe

Anti-Matter

"Anti-matter", so-called, exists here in our environment. A positron is the "anti-particle" of the electron. But the positron is "anti" to the electron in little more than charge. Its mass and energy are measured by the gram and erg, whereas a genuinely "anti" electron would measure its mass by the *marg*, its energy by the *gre*, and its arrow of time would dart backwards. Perhaps such an anti-universe exists with mirror symmetry with ours on the other side of T_0 somewhere beyond infinity. But if so we would never be aware of it because it could never meet up with any point of our universe in the coordinate system of x, y, z, iT.

Universal Rotation

One of the most striking facts of the universe is that everything in it rotates--atoms, planetary systems, and nebulae. Why should this be so? What is implied? Every hydrogen atom has spin. For example, in a proton-precession magnetometer the spins of all these protons in a bottle of water are axially aligned by a solenoid around the bottle and when this coil current is switched off each spinning proton suffers the torque of the local magnetic field, which makes it precess at a rate dependent on the strength of that field. It has generally been assumed that spin axes of matter are normally oriented randomly. But if matter comes into being as the twin of potential energy (perhaps as sub-atomic particles) any ambient field from the body would polarize the nascent spins to the counter sense. Hence, with each particle born, the particle and the host body would receive equal and opposite angular momenta. If we assume the sun to be wholly hydrogen and add all the momenta of its constituent protons, and compare this sum with the angular momentum of the sun, we fall short by some orders. Moreover, the angular momentum of the sun (which carries most of the matter) is only one fiftieth of the angular momentum of the solar system, so clearly the assumptions of the calculation cannot be the whole answer. Nevertheless, I suspect that it is in this direction that the enigma of universal rotation should be sought.

Notwithstanding this suggestion, universal rotation may derive from fundamental cosmic properties seeing that Hubble's constant has the dimensions of $1/T$ which is the same as the dimensions of angular velocity. There is however a vector difference: as we move out along the radius of a rotating body, linear velocity normal to the radius increases directly in proportion to the radius. The same is true with increasing cosmic distances except that the waxing velocity is along the radius not normal to it. Are rotation and Hubble dispersion related as are magnetic and electric vectors?

Standard theory assumes that the Hubble velocity increase is constant, i.e. that it is directly proportional to distance. However, this cannot be true. For, as pointed out by others the Hubble constant gives the observed present rate not only of the cosmos, but also of the Earth-Moon system, and of Earth expansion. However, in each case linear retrogression from the present gives obviously false rates. The whole cosmos would be concentrated in a small space 1.9 aeons ago, Moon would be back here at about the same time, and Earth would have reduced to a very small body - all this within the middle of the Proterozoic. Clearly Hubble's "constant" must be time-dependent and regress asymptotically to T_0.

The Solar System as G changes

Application to the solar system of the continuous creation of matter and of the change in G with time implies changes in the diameters of the planetary orbits as well as variation in the luminosity of the sun, which should show up in the geological record. Chin and Stothers (1975) have investigated this question in the case of multiplicative creation (that is where mass grows according to its own concentration) and they found "the rather surprising result that [these solar models] are nearly the same as the final model based on standard theory! This occurs in spite of the widely disparate initial masses, occasioned by the use of a full range of choices for t_0. The reason for this similarity is that the effect of a larger G in the past is to

increase the luminosity, whereas lower stellar mass decreases it." They go on to investigate the effects on the orbits, and concluded that the deduced temperatures at the surface of the earth do not conflict with palaeogeographical evidence.

Do rocks grow?

Chin and Stothers however then ask: "But why are well-preserved Precambrian and early Cambrian fossils in essentially perfect shape if their masses have increased by a significant percentage?" This enigma arises from their assumption (following Dirac) that in multiplicative creation all atoms would multiply kind for kind - silicon for silicon and so on. However surely this would be in the highest degree improbable. The likely kind of multiplicative creation would be in the simplest state possible - "infra-quarks" or whatever. In due course the first atoms would be the simplest - atomic hydrogen, which would diffuse out of the rock either as gas or as water. Every volume of sedimentary rock in a geosyncline suffers transit through it of several times its own volume of fluids, mainly water but also hydrocarbons as gases or liquids, yet no distortion of fossils results. In fact the great majority of fossils do show large degrees of strain, but not from such passage of fluids, but from ordinary compaction under load and from tectonic deformation of the rock.

Towe (1975) has claimed that "if atomic distances vary as t^{-1} as required by Dirac's large-numbers theory, then the *d*-spacings in crystal lattices in geologically older minerals should be observedly different from those in the same minerals forming today. The geological evidence, however is strongly against such a prediction: the lattice dimensions of a 3×10^9 year-old quartz crystal are the same as the lattice dimensions of quartz grown in the laboratory." Of course they are, and would be under Dirac's theory. Quartz would have *grown* initially with the *d*-spacings appropriate to the time of origin. But as the ambient fields and "constants" change, so would the size of the unit cell whatever its juvenility or senility. Gittus (1975) and Towe *(loc. cit.)* make the same false assumption as do Chin and Stothers above, that silicon would replicate as silicon and so on.

In any case cosmic empiricism suggests that growth of matter is a function of its own concentration, and geological empiricism suggests that most growth takes place in the core, and perhaps to a less degree in the mantle. The controlling function may involve density of matter and perhaps pressure and temperature.

Earth's Surface gravity

Stewart (1977) has summarized five sets of data which put limits on the former magnitude of gravity at the earth's surface (g) compared to the present magnitude (g_o): "1. The permanent existence of a terrestrial atmosphere over the last 3.7×10^9 years $(0.33\ g_o < g)$. 2. Dimensions of vertebrates: Jurassic *Apatosaurus* $(g < 1.2\ g_o)$ and Upper Cretaceous *Pteranodon* $(g < 2\ g_o)$. 3. Miocene overconsolidation of the London Clay $(0.5\ g_o < g \leqslant g_o)$. 4. Phanerozoic upper mantle mineralogy $(0.4\ g_o < g < 2.2\ g_o)$. 5. Crustal mineralogy during the Phanerozoic $(0.5\ g_o < g < 1.4\ g_o)$ and Precambrian $(0.5\ g_o < g < 1.9\ g_o)$." Stewart goes on to state that "These limits can be used to put constraints on hypotheses involving Earth expansion and changes in the universal constant of gravitation." This corollary is only true if the further assumption is made that the matter and mass of the earth have been essentially constant. For my part I am convinced that this assumption is false, and on a cosmic scale leads to the absurdity of Le Maître's ultra-embryo already discussed.

Are we alone?

A decade ago I commented in another oration (Carey 1967) that one of the puzzles of the universe is why we have not yet recognized signals from other thinking beings. We are flooded with diverse radiation from all over the galaxy and beyond, but have found no sign of wilful modulation. Surely, with so many millions of suns comparable to ours, it is highly improbable that we are the only cognitive beings, or the most

advanced. Why have we not heard from them?

One answer is that they would not have seen any evidence of us--yet. Or is eventual self-destruction inherent in any competitive evolutionary system soon after it achieves the technical competence to do so, so that there never has been, nor ever will be, a race much more advanced than ours? Then, again, perhaps we are not searching the right medium. A century ago we were quite unaware of radio waves. Perhaps when we learn to modulate and demodulate coherent light efficiently, we may find all the messages we seek. After all, a light channel can carry vastly more information than any radio channel, and may well be the preferred medium for those who know how to use it. Shall we suddenly break in on a vast communication system of the galaxy? Perhaps we have to learn to communicate by still some other carrier as yet unrecognized.

The Arrow of Time

The cosmological principle is the analogue in cosmology of the principle of uniformitarianism in geology. In its "perfect" form it postulates that the laws of physics are invariant through space-time, that a sample of the universe of sufficient size does not differ significantly from any other sample elsewhere in space or at some other time. The perfect cosmological principle (which is the geologists' principle of uniformitarianism *without* the geologists' law of superposition) supports steady-state theories, but not evolutionary theories, nor increasing entropy, nor the arrow of time.

For my part, empiricism does not support the steady state in respect of time. Pochoda and Schwarzchild (1964) found that steady-state additive models predicted solar neutrino ratios several orders too high, whereas Chin and Stothers (1975) showed that multiplicative creation (with matter increasing in proportion to its own concentration) predicted a solar neutrino flux consistent with standard solar models. Moreover, neither in local astronomy nor in gross cosmology is *now* the same as *then*. For example, if we reverse the observed acceleration of the moon, the moon would be back at the earth during the Proterozoic Era. Similarly if we reverse the recession of the galaxies they would herd in a small space a few aeons ago. The oldest rocks known on Earth or Moon are between three and four aeons old and meteorites have similar age. T_o for all seems to be a few aeons ago. These regressions are probably too simple and perhaps should be exponential, which would extend T_o asympotically towards infinity. But neither the Earth-Moon system nor the whole cosmos appear to be invariant with time, as would be required by the perfect cosmological principle.

The perfect cosmological principle and its steady-state corollary seem to have another fatal objection arising from the gross thermodynamic disequilibrium of the universe. Olber, early last century, found that in an equilibrium system each body would eventually radiate as much energy as it received, and universal light would saturate the sky. This clearly was not so--hence Olber's paradox of stars in a black sky. In a steady-state universe without zero time thermodynamic equilibrium should have been attained. Truly we might postulate a dynamic equilibrium, but such a system would be inherently unstable, and could hardly represent a steady-state universe. Escape from this dilemma could be conceived in an expanding universe where all matter approached the seeable boundary of the universe at the velocity of light before thermodynamic equilibrium could be attained. It is true that the red-shift implies an energy sink, and that as the recession velocity approaches the velocity of light, the radiant energy back along its path approaches zero. However there would be an infinity of such receding galaxies, and the energy return would be the product of tending-toward-zero and tending-toward-infinity!

The problem of zero time, and of mirror symmetry across it, evaporates in the null model, because zero time must then be pursued back towards the initial infinity, before the appearance of a random perturbation. The arrow of time has not deflected since this infinity, hence the empiricism of our intuition.

Creation and The Spiritual

Creation may be considered in two distinct ways - as a question for physics or for theology. Even though these may become entwined in conceptual discussion, I stated earlier that they can be separated just as the real and imaginary terms in a complex mathematical statement can be separated into two discrete statements, one containing all the real terms and the other containing all the imaginary terms.

People differ on the validity of a spiritual world. I have no personal experience of anything spiritual so I can neither affirm nor deny the validity of a spiritual domain. However quite a number of my close acquaintances positively affirm such experience. I am satisfied that they are truthful witnesses, though this does not exclude the possibility of their self-deception.

If then we do not exclude the spiritual, nevertheless it can be entirely separated from the physical as in the foregoing mathematical analogue. No recorded mass, charge, magnetic field, or electromagnetic radiation has been attributed to a soul. Heaven and hell have no physical location in the mantle, on the moon, or in interplanetary, or interstellar space. All of us have had the clearest and most detailed visual images in dreams or other states of trance, but no light waves are associated with them, and from my own experience the time scale of sequential events can be compressed by several orders.

It is true also that the solution to difficult problems may become obvious in our disturbed sleep, but I do not regard this as external inspiration. Rather, during our dreaming sleep the brain churns over the waking problem, but with an important difference: it is no longer restricted by the constraints of our relevant prejudices. So often it is what we think we know which blinds us to the truth, and to the solution to our problem.

Thus none of the phenomena of dreams, or visions, or inspiration, known to me demand explanations beyond natural science. Creation itself is no longer a problem because in the null universe nothing - not mass, not charge, not energy - is created. The material universe is integral without intervention of the spiritual. But this does not deny or exclude the possibility of other phenomena.

CONCLUSION

Commencing with a universal void, the inseparable twins of positive and negative charge, of north and south polarity, of momentum vectors and cancelling momentum vectors, of rotation and counter rotation, of inertial mass-energy and gravitational potential energy, gravitational attraction and cosmological repulsion, have waxed wider with time, with increasing entropy and mean temperature, but always reduce to zero in the ultimate reckoning. For how else could the immensity of the universe come into being?

When the Indians invented zero to make a continuous series of numbers from minus infinity to plus infinity the concept was so obvious that we marvel that it had not been thought of before. So also the universal null emerges with obvious simplicity, as inevitable.

POSTSCRIPT

Since delivering this address I have found that Edward P. Tryon had published in *Nature* of December 14, 1973 a universal null hypothesis under the title, "Is the universe a vacuum fluctuation?" Tryon concluded that the universe did appear from nowhere about 10^{10} years ago, and to be consistent with the laws of physics the net value of all conserved quantities must be zero. His universe is homogeneous, isotropic,

and closed, and consists equally of matter and anti-matter. Tryon also pointed out that inertial mass and gravitational potential energy are intrinsically equivalent and mutually cancelling. He also quotes Bergmann's argument that a closed universe must have zero total energy, because it would be topologically impossible for any gravitational flux lines to go outside the limits of the universe, and hence the sum of the energy of the whole universe must be zero.

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A NEW GENUS AND SPECIES OF FLOUNDER (F. PLEURONECTIDAE) WITH NOTES ON OTHER TASMANIAN SPECIES

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(with two tables and one plate)

ABSTRACT

Six species of pleuronectids, *Ammotretis lituratа* (Richardson), *A. macrolepis* McCulloch, *A. rostratus* Günther, *Azygopus pinnifasciatus* Norman, *Rhombosolea tapirina* Günther and *Taratretis derwentensis* gen. et. sp. nov., are found in Tasmanian waters and a key for their identification is given. The new genus is defined and the species described. In addition, *Ammotretis tudori* McCulloch is placed in synonymy with *A. lituratа* and notes on *R. tapirina* are provided. A second known specimen of *A. macrolepis* is described and the features which distinguish it from *A. lituratа* are noted.

INTRODUCTION

The family Pleuronectidae is represented in Australia by two subfamilies. One of these, the Samarinae, is represented by a single species recorded only from Queensland. The second subfamily, the Rhombosoleinae, is exclusively a Southern Ocean group with six of the eight known genera recorded from Australia and New Zealand (Norman 1934).

Johnston (1883, 1891) listed four species of pleuronectids from Tasmania, *Ammotretis rostratus* Günther, *Rhombosolea monopus* Günther, *Rhombosolea tapirina* Günther, and *Solea lituratа* Richardson. McCulloch (1914) added *Ammotretis macrolepis* McCulloch and *A. tudori* McCulloch to this list. Lord and Scott (1924) add *Rhombosolea flesoides* Günther but omit *R. monopus* and *S. lituratа*.

In his revision of the subfamily Rhombosoleinae, Norman (1926) recognized five species; all three *Ammotretis* species, *R. tapirina* and a new species, *Azygopus pinnifasciatus* Norman. *R. flesoides* and *R. monopus* were made junior synonyms of *R. tapirina* and a New Zealand species, *R. plebia* Richardson, respectively. However he doubted the validity of Australian records of *R. plebia* and suggested that they were misidentifications of *R. tapirina*. Uncertain of the true position of *S. lituratа*, Norman tentatively placed the species in synonymy with *A. tudori*.

These species are accepted by subsequent authors (Munro 1957, Scott 1962). However, McCulloch (1929) retained *S. lituratа* as an *Ammotretis* species, distinct from *A. tudori*. The validity of *A. macrolepis* and its consequent exclusion from *A. tudori* has been questioned (Norman 1934), but the species which was described from a single specimen was retained.

In the following paper a new rhombosolein fish is added to the Tasmanian records. The validity of *A. macrolepis* and *A. lituratа* are also discussed.

METHOD

A total of 26 measurements (table 1) was recorded from specimens of *Ammotretis macrolepis*, *A. lituratа* and the new species. Most of these are standard measurements used by Lagler, Bardach and Miller (1962) but some require clarification.

The upper and lower snout measurements refer to the direct lengths from the tip of the snout to the anterior margins of the upper and lower eyes respectively; the eye length being the longitudinal diameter of the upper eye. Apart from fin ray heights, all measurements were direct; the maximum length of the longest ray of the appropriate fin was used for each fin ray measurement.

Measurements presented in tables 1 & 2 are expressed as thousands of standard length (S.L.); the standard lengths being given in millimetres.

The transverse scale count (Tr) was taken from the dorsal border above the pectoral fin origin, transversely to the anal fin.

Means and modal values for measurements and fin counts, respectively, are bracketed in the species description.

The range (R) of a ratio of the number of rays in the right and left pelvic rins, Pr and Pl respectively, was used as a key character. This pelvic ratio (P.R.) was designated by:

$$P.R. = \frac{Pr}{Pl} \text{ and } R = P.R._{minimum} - P.R._{maximum} \text{ where}$$

$$P.R._{minimum} = \frac{Pr_{minimum}}{Pl_{maximum}} \text{ and } P.R._{maximum} = \frac{Pr_{maximum}}{Pl_{minimum}}$$

RESULTS AND DISCUSSION

Six species of pleuronectids are hereby recognized as occurring in Tasmania and a key for their identification is given below.

KEY TO THE TASMANIAN PLEURONECTIDAE

1. One pelvic fin.....*Rhombosolea tapirina* Günther
   Two pelvic fins.....2
2. Right pelvic free from anal (R = 1.67 - 2.20).....*Azygopus pinnifasciatus* Norman
   Right pelvic joined to anal.....3
3. Sum of ray elements of both pelvics less than 13 (10-12).....4
   Sum of ray elements of both pelvics greater than 13 (15-17).....5
4. Pelvic Ratio less than 1.50 (1.00-1.20). Dorsal and anal fins naked. Snout not produced into fleshy hook. Anterior dorsal and right pelvic rays bifurcated, without blunt serrations.....*Taratretis derwentensis* gen. et. sp. nov.
   Pelvic Ratio greater than 1.50 (1.75-2.33). Dorsal and anal fins scaled on ocular side. Snout produced into long fleshy hook. Anterior dorsal and right pelvic rays simple, serrated.....*Ammotretis rostratus* Günther
5. Pelvic Ratio less than 2.00 (1.50-1.67). Left pectoral with fleshy tubercle; less than 0.65 length of right.....*Ammotretis lituata* (Richardson)
   Pelvic Ratio greater than 2.00 (2.4). Left pectoral without tubercle; greater than 0.65 length of right.....*Ammotretis macrolepis* McCulloch

Sub-family RHOMBOSOLEINAE

Genus *TARATRETIS* gen. nov.

Genotype: *Taratretis derwentensis* sp. nov.

Diagnosis.

Body ovate, compressed. Eyes on right side; eyeballs not scaled. Interorbital space scaled. Jaws almost symmetrical. Snout not produced into a fleshy hook. Nasal organ of blind side nearly opposite to that of ocular side; olfactory laminae few, parallel to one another and to axis of the body, without central rachis. Dorsal fin commencing some distance from extremity of snout; anterior rays branched, not free and without distal serrations. Dorsal and anal fins scaleless, no basal sheath. Ventral rays branched.

Affinities.

The position and structure of the nasal organ is important in the classification of the Heterosomata (Norman 1926, 1934). The median rachis of the nasal organ has been lost in the following four genera of Rhombosoleinae: *Rhombosolea*, *Taratretis* and the sole-like genera, *Ammotretis* and *Peltoramphus*.

Taratretis resembles *Rhombosolea* and differs from the sole-like genera in the anterior vertical fin ray structure and in the absence of a rostral hook. However the genus parallels *Ammotretis* and *Peltoramphus* in the other sole-like features outlined by Norman (1926). Most of these characters plus the presence of a left pelvic fin, are markedly different from those in *Rhombosolea*. Thus, in form, *Taratretis* would appear to be intermediate between *Rhombosolea* and the sole-like genera but possibly with an independent phylogeny.

Taratretis derwentensis sp. nov.
Plate 1

Material.

Holotype:61.0 mm S.L., female, collected by author in Derwent Estuary off Nutgrove Beach (147°21'E, 42°55'S), seined in 3 metres, 30.3.77. Tasmanian Museum Reg. No. D1305.

Paratypes: 18 specimens, all collected by author from Derwent Estuary: 2 specimens, 46.6, 51.7 mm S.L., Blackmans Bay (147°20'E, 43°00'S), seined, 13.4.76; 16 specimens, 27.0-62.6 mm S.L., Nutgrove Beach, seined, 16.1 - 14.2 - 28.2 - 30.3 - 15.4 - 27.4.77 (Specimens to be distributed between the Australian Museum, Queen Victoria Museum and the Tasmanian Museum).

Other material: 2 specimens, 48.6, 62.1 mm S.L., West Beach, Stanley (145°15'E, 40°45'S), seined by author 16.2.78; 1 specimen, 66.9 mm S.L., Hawley Beach, Port Sorell (146°32'E, 41°09'S), seined by author, 18.2.78; 1 specimen, 86.2 mm S.L., Tinderbox Bay (147°20'E, 43°04'S), dredged by Mr. M. Jacobson, 21.3.78.

Description.

Depth of body 2.02 - 2.34 (2.22) in the length, head length 3.64 - 4.07 (3.87). Snout short, not produced to form a hook, extending to level of middle lower eye. Lower eye slightly in advance of upper eye, each almost equidistant to ventral and dorsal profiles respectively. Longitudinal diameter of upper eye 3.0 - 4.2 (3.6) head length; approximately equal to upper snout length; greater than eight times interorbital width. Mouth small, almost symmetrical, jaws equally curved on each side; lower lip on ocular side fringed. Teeth small, acutely pointed; in bands on jaws of blind side and anterior part of mandible on ocular side. Maxillary extension variable, usually reaching to below anterior margin of lower eye. Nasal organs symmetrical, with pair of small pores on each side; anterior pores with simple tentacles on their posterior borders; 4 - 5 olfactory laminae parallel to each other and to main axis of body; no central rachis. Upper angle of gill opening just above base of pectoral fins, gill rakers short, tubercular, 9 - 13 (12) on lower part of anterior arch. Scales small, ctenoid, more denticulate on ocular side; entire over head and body; imbricated in distinct longitudinal rows; 75 - 83 (79) in lateral line; Tr 48 - 56 (51); eyeballs, dorsal and anal fins naked. Lateral line with a low curve above pectoral fin; a short supratemporal branch not reaching dorsal fin. Dorsal fin commencing away from snout apex, directly anterior to nasal organs; no basal sheath; rays bifid, not free or serrated, 70 - 80 (75); membraneous folds on blind side well developed. Anal similar to dorsal, 51 - 59 (53) rays. Right pelvic originating over or behind mid-orbital level of lower eye; rays bifid, last two longest. Left pelvic shorter than right; 5 - 6 (6) rays, first opposite the fifth on ocular side. Right pectoral 8 - 11 (10) rays. Left pectoral 1.1 - 1.5 (1.26) in right; 7 - 9 (7) rays. Caudal rounded, all

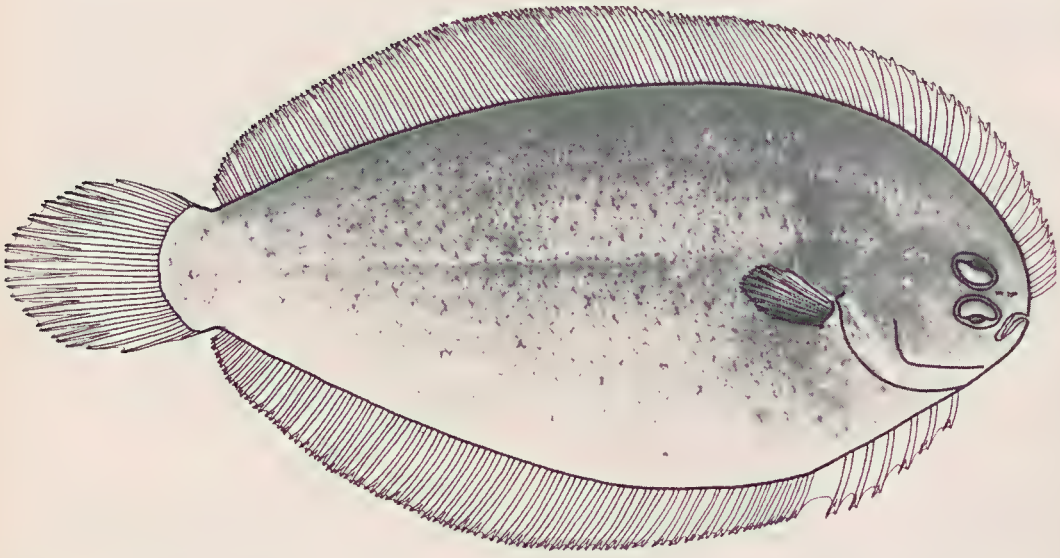

PLATE 1.- *Taratretis derwentensis* gen. et sp. nov.; holotype; 61.0 mm S.L.; seined in 3 m at Nutgrove Beach in the Derwent Estuary; 30.3.77. Tasmanian Museum Reg. No. D1305.

rays scaled on both sides to approximately half length of median rays; rays 18, middle branched 10 - 13 (12), outer simple 4 - 8 (6). Caudal peduncle short. Intestine elongate, about 3 times length of head (0.78 of S.L.).

Dimensions.

As given in table 1.

Coloration.

Natural - Ocular side sandy with numerous scattered light and dark areas each covering about 2 - 6 scales. Scale edges darker. Fin rays lighter interdispersed with orange and black markings; membranes transparent with irregular white areas over quarter of total area. Blind surface white. Formalin - Preserved specimens lighter, with pattern as above. Fins uniform light grey.

Size.

Largest specimen collected 102.4 mm total length.

Distribution.

Evidence from initial sampling indicated that the species may be endemic to beaches in the vicinity of the Derwent Estuary, however specimens recently produced from two Bass Strait localities indicate a wider distribution pattern than first expected.

TABLE 1

TARATRETIS DERWENTENSIS GEN. ET SP. NOV.
Dimensions of Holotype and 18 Paratypes from the Derwent Estuary, southern Tasmania. First Line: standard length, absolute dimensions, mm; other lines: relative dimensions, thousandths of standard length.

	Holotype		Paratypes	
	x	Range	$\bar{x}$	S.D.
Standard length	61.0	27.0 - 62.6	39.07	-
Total length	1256	1215 - 1255	1236.0	2.99
Head	246	248 - 275	258.3	1.73
Snout, upper	64	60 - 78	70.3	1.00
Snout, lower	56	41 - 66	49.5	1.21
Eye	64	60 - 85	71.3	1.61
Interorbital	5	3 - 7	5.2	0.28
Length base left pectoral fin	26	19 - 27	23.6	0.57
Length left pectoral fin	89	72 - 103	89.0	1.57
Length base right pectoral fin	28	25 - 32	28.2	0.46
Length right pectoral fin	118	101 - 118	112.0	1.14
Length base left pelvic fin	30	27 - 44	33.4	0.94
Height left pelvic fin	62	58 - 89	74.4	1.55
Length base right pelvic fin	153	137 - 182	156.1	2.75
Height right pelvic fin	85	84 - 104	93.0	1.21
Length base dorsal fin	982	943 - 986	966.8	2.59
Height dorsal fin	118	106 - 145	123.4	1.89
Length base anal fin	749	693 - 805	752.0	6.73
Height anal fin	116	107 - 141	123.0	1.61
Length unbranched caudal rays	157	146 - 176	158.8	1.93
Length branched caudal rays	241	213 - 267	235.2	3.19
Depth vent	410	354 - 417	378.0	3.57
Depth maximum	494	425 - 489	449.5	4.95
Depth caudal peduncle	138	125 - 137	131.7	0.86
Length maxillary	59	54 - 70	61.9	0.84
Length snout to vent	257	253 - 319	285.1	4.42

Genus *AMMOTRETIS* Günther, 1862

Ammotretis lituratus (Richardson, 1843)
Synonym: *Ammotretis tudori* McCulloch, 1914

Material.

Seventeen specimens all collected by author and held in personal collection : 2 specimens, 156.0, 241.4 mm S.L., St. Helens Point (148°22'E, 41°16'S), speared, 5.12.76; 6 specimens, 54.2 - 114.1 mm S.L., Nine Mile Beach, Swansea (148°08'E, 42°06'S), seined, 8.3.77; 1 specimen, 70.3 mm S.L., Kingston Beach (147°20'E, 42°58'S), seined 16.3.77; 2 specimens, 73.3, 77.4 mm S.L., Safety Cove, Port Arthur (147°51'E, 43°10'S), seined, 30.3.77; 5 specimens, 54.9 - 62.5 mm S.L., Point Bagot, Swansea (148°14'E, 42°06'S), seined, 8.6.77; 1 specimen 265.3 mm S.L., Point Bagot, Swansea (148°14'E, 42°06'S), seined, 17.1.78.

Comments.

McCulloch (1914) described *Ammotretis tudori* from Bass Strait and provided a key to the known members of the genus, which however did not include *A. lituratus*

(Richardson). Norman (1926) was first to recognize Richardson's species as an *Ammotretis* and considered it as possibly conspecific with *A. tudori* but failed to give reasons. Specimens collected from several localities around Tasmania, including Port Arthur the assumed type locality of *A. liturata*, fit the description of that species and are also conspecific with the holotype of *A. tudori*. These findings support Norman's sentiments, hence the two species are treated here as synonymous, with the older name *A. liturata* taking precedence.

The question of synonymy would have been more reliably elucidated had the holotype of Richardson's species been examined. However a detailed literature search, followed by an investigation of the holdings of the Tasmanian, Queen Victoria and Australian Museums failed to locate the type and have raised doubts about its current existence.

Ammotretis macrolepis McCulloch, 1914

Material.

One specimen 55.1 mm S.L., off Flinders Island, Bass Strait, J. Grant, dredged from Tasmanian Sea Fisheries vessel 'Challenger', May 1977. Tasmanian Museum Reg. No. D1306.

Comments.

A comparison of Mr. Grant's specimen with the holotype indicates their similarity except that McCulloch's specimen exhibits a greater number of vertical fin rays; 90 dorsal and 59 anal rays compared with 80 and 52 rays respectively. Although the variation is considerable, it is not atypical for this group of fish. In comparison two less intraspecifically variable characters, namely the pelvic fin ray counts, are both identical for both specimens and unique to the genus.

Colour on the ocular side is light grey and white with faint evidence of darker ocelli. The blind side is white.

This species is most similar to *A. liturata* and its distinctness from that species has been questioned by Norman (1926, 1934). *A. macrolepis* differs primarily by the absence of blunt serrations on the edges of the anterior dorsal and right ventral rays, the absence of a fleshy tubercle on the right pelvic fin and the unique pelvic ratio.

A comparison of a number of different proportions (Table 2) made on similar sized specimens of the two species is of limited use because of small sample sizes, however some trends are evident. The relative eye diameters, the lengths of the longest unbranched caudal rays and the length and base lengths of the right pectoral fins show differences. The relative lengths of the bases of the anal and left pectorals are significantly different at the 0.01 level. The ratios of the pectoral lengths are very different for the two species (P less than 0.005). The left pectoral of *A. macrolepis* is slightly shorter than the right, however for *A. liturata* a reduction in the left pectoral length has been accompanied by a comparative elongation of the right.

Genus *RHOMBOSOLEA* Günther, 1862

Rhombosolea tapirina Günther, 1862

Those specimens previously identified as *Rhombosolea sp.* (Scott 1976), *R. monopus* (Johnston 1883, 1891) and *R. flesoides* (Lord and Scott 1924), appear to be misidentifications of the very variable species *R. tapirina*. Some specimens have assumed a very rhomboidal shape similar to *R. plebia*, whereas other adult characters including the form of the snout, are typical of *R. tapirina*. To complicate the issue the fleshy snout is usually reduced in juveniles. Clearly, if a second species does exist, it must be very similar externally to *R. tapirina*.

TABLE 2

COMPARATIVE MORPHOMETRY OF SMALL SAMPLES OF *AMMOTRETIS LITURATA* (RICHARDSON) AND *A. MACROLEPIS* MCCULLOCH

First line: standard length, absolute dimensions, mm; other lines relative dimensions, thousandths of standard length.

	Ammotretis lituratа (n=5)			*Ammotretis macrolepis* (n=1)		
	Range	$\bar{x}$	S.D.	x	t_4	Signif.
Standard length	54.9 - 62.5	59.04	-	55.1	-	-
Total length	1207 - 1244	1223.4	13.70	1193	1.996	-
Head	270 - 284	275.6	5.13	267	1.531	-
Snout, upper	110 - 119	115.0	4.18	111	0.873	-
Snout, lower	72 - 81	78.8	3.84	73	1.381	-
Eye	57 - 62	59.8	1.92	69	4.366	*
Interorbital	5 - 11	7.4	2.19	4	1.417	-
Length base left pectoral fin	26 - 30	28.6	1.52	17	6.982	**
Length left pectoral fin	54 - 62	58.4	3.35	68	2.607	-
Length base right pectoral fin	33 - 38	34.0	2.24	26	3.266	*
Length right pectoral fin	107 - 120	113.0	4.94	95	3.320	*
Length base left pelvic fin	27 - 35	30.2	3.35	40	2.673	-
Height left pelvic fin	54 - 80	69.4	9.77	57	1.157	-
Length base right pelvic fin	182 - 234	203.4	18.98	189	0.692	-
Height right pelvic fin	97 - 109	105.0	5.10	120	2.685	-
Length base dorsal fin	959 - 976	968.0	6.42	951	2.469	-
Height dorsal fin	132 - 144	137.4	4.65	129	1.642	-
Length base anal fin	745 - 754	749.0	4.18	715	7.641	**
Height anal fin	130 - 148	138.6	7.11	131	0.973	-
Length unbranched caudal rays	157 - 170	164.2	5.48	191	4.452	*
Length branched caudal rays	218 - 235	227.6	6.26	236	1.223	-
Depth vent	396 - 438	421.4	17.93	409	0.631	-
Depth maximum	463 - 497	480.6	12.41	461	1.440	-
Depth caudal peduncle	122 - 131	125.8	3.55	115	2.767	-
Length maxillary	49 - 54	51.2	1.92	51	0.095	-
Length snout to vent	239 - 304	276.4	25.76	249	0.971	-
Right pelvic ray count	9 - 10	9		12		
Left pelvic ray count	6	6		5		

A detailed study of the anatomy and morphometrics of Australian collections is necessary before this problem can be elucidated.

ACKNOWLEDGEMENTS

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(ms. received 20.6.77)

NOTES ON THREE SPECIES OF TASMANIAN SEA CUCUMBERS INCLUDING ONE SPECIES THAT BROODS ITS YOUNG IN THE COELOME. (HOLOTHURIOIDEA: PHYLLOPHORIDAE, CAUDINIDAE)

by V.V. Hickman
Hobart

(with 44 text-figures and one plate)

ABSTRACT

Two specimens of *Neocamphicyclus lividus* Hickman out of 135 dissected and examined were found to contain young in the coelome. *Neothyonidium dearmatum* (Dendy and Hindle), previously found on the coasts of New Zealand and Victoria is recorded from Tasmania for the first time. *Paracaudina luticola* Hickman, formerly known only from the caudal region of its body, is now described from two complete specimens.

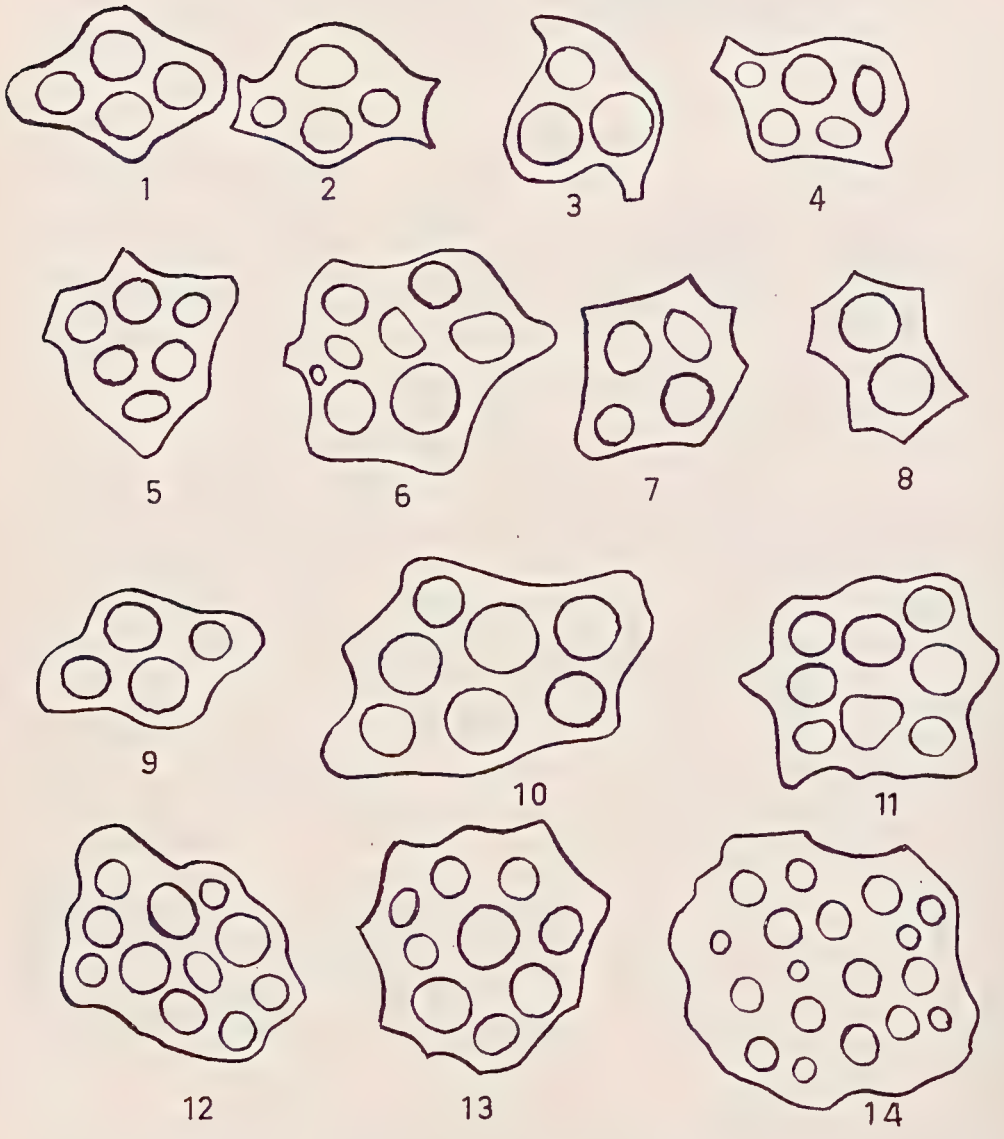
Family PHYLLOPHORIDAE

Neocamphicyclus lividus Hickman with young in the coelome.

During low tide on 19th March, 1954, seventy specimens of *Neocamphicyclus lividus* Hickman (1962) were collected from under stones at Pirates Bay, Eaglehawk Neck, Tasmania. In the two preceding months 105 specimens of the holothurian had been taken from the same locality making the total collected 175. Of these 121 were dissected and examined in searching for endoparasitic Turbellaria. One of the holothurians dissected was found to contain another of the same species within its coelome. The latter specimen was relatively large, being more than half the length of the one containing it. The occurrence of such a large specimen in the body of another and the fact that no young had been found in the other 120 specimens dissected caused the writer to think that the case was one of teratogeny. It was described as such in a paper submitted for publication. The reviewer of the manuscript suggested that the occurrence might be a case of coelomic incubation. Further specimens were therefore examined, ten from the original locality and four from the shore of Recherche Bay, Catamaran. The latter specimens had been collected on 3rd December, 1952, but not examined. One was now found to be brooding 23 young in its coelome. The reviewer of the manuscript was thus proved to be quite correct in his suggestion.

The brooding adult collected at Pirates Bay on 19th March, 1954, had the usual characters of the species. It measured 45.0 mm long and 10.0 mm in greatest width. Calcareous particles (text-figs 1-8) in the skin of the body were in the form of irregular flat plates without towers. They measured 33µm - 57µm in greatest diameter and had two to eight holes, the most frequent number being four. The ring vessel had three long Polian vesicles and a madreporic canal. The ovary was small with about 22 tubules, some containing ova.

The single young one in the coelome of the adult measured 28.0 mm long and 5.0 mm in greatest width. It was lying longitudinally in the body-cavity but was not free. Its narrow posterior part, about 4.0 mm in length, was firmly embedded amongst the numerous muscle fibres extending from the cloaca to the wall of the coelome. The anal extremity lay in a small depression amongst the muscle fibres near the posterior end. In most features the young one resembled the adult. However it had only 11 tentacles in the outer ring. Calcareous particles (text-figs 9-14) in the skin of its body were flat plates 51µm - 75µm in greatest diameter. They had 4-18 holes and were larger than



FIGS 1 - 14 - *Neoamphicyclus lividus* Hickman; Calcareous particles. 1 - 8 of adult, 9 - 14 of young one from coelome of adult.

the particles of the adult. The calcareous ring was normal. The gut was narrow, without colour and the usual contortions. It contained no grit, but was filled with coagulated body fluids. Respiratory trees were small and only about one quarter the length of the body-cavity. The ring vessel had one large Polian vesicle and a madreporic canal. No gonads were present.

The brooding female found at Recherche Bay on 3rd December 1952, was strongly contracted, the introvert and tentacles being withdrawn. It measured 31.0 mm long and 10.0 mm in greatest width. The ovary was small with only twelve tubules, six on each side of the dorsal mesentery. Some of the tubules contained one or two eggs, 370µm. in diameter, that showed no signs of segmentation. Twenty-three young were present in the coelome. They varied in size, the smallest being 3.5 mm long and 1.8 mm wide, while the largest were 7.0 mm long and 2.1 mm wide. Most of them were colourless, a few of the largest being pale slaty-blue. In all the pedicels of the three ventral ambulacral zones were strongly developed, those of the two dorsal zones being scarcely visible. In the largest specimens the tentacles were well formed and the ring vessel had one Polian vesicle. The intestine was large and had the usual contortions. The respiratory trees consisted of a pair of short unbranched tubes opening into the cloaca. In all juvenile stages calcareous particles were numerous in the skin and resembled those of adults. In a young stage only 3.5 mm long the particles measured 51µm. - 84µm. in diameter and had 2 - 14 holes. As in adults plates with four holes were the most numerous.

Remarks: Booloo tian (1966) lists seven holothurians that brood their young in the coelome. Three belong to the Phyllophoridae, the others are apodous species. *Neoamphicyclus lividus* appears to be the first Australian holothurian to be recorded as practising coelomic incubation.

PLATE 1. - *Neothyonidium dearmatum* (Dendy and Hindle) extended.

Neothyonidium dearmatum (Dendy and Hindle)
Phyllophorus dearmatus Dendy and Hindle 1907
Phyllophorus dearmatus Joshua 1914
Phyllophorus dearmatus Mortensen 1925
Phyllophorus dearmatus Clark 1938
Lipotrapeza darmatus Clark 1946
Lipotrapeza dearmatus Dawbin 1950
Neothyonidium dearmatum Heding and Panning 1954
Neothyonidium dearmatum Pawson 1963
Neothyonidium dearmatum Pawson 1970

When preserved in 70 percent alcohol the Tasmanian specimen has dark brown tentacles, a light brown introvert and a greyish white body. When fully extended the body is fusiform and slightly curved (plate 1). It measures 105 mm long and 16.0 mm in greatest width. The introvert is large and somewhat bulbous. There are 20 tentacles disposed in two rings, an outer ring of 10 large tentacles and an inner ring of 10 small ones. In both rings the tentacles are arranged in pairs. Pedicels occur on the posterior half of the introvert, where they are confined to the ambulacra. On the rest of the body the pedicels are present in both the ambulacral and interambulacral zones. The anus is surrounded by ten small papillae.

Calcareous particles occur in the skin of the introvert and anal papillae but are absent from the rest of the body including the tentacles and cloaca. However, a perforated plate is found at the end of each pedicel. The calcareous particles of the introvert (text-figs 15-20) are widely scattered. They have the form of more or less rounded plates 75µm. - 100µm. in diameter and perforated by 8 - 22 holes. Many of the plates have a low tower with two columns (text-fig. 20). In the skin of the anal papillae the calcareous particles are mainly branched rods (text-figs 21 - 24). They are about 51µm. - 105µm. long, and some are perforated with a few holes. The particles appear to unite forming a kind of basketwork in the skin surrounding the papilla.

Locality: The single specimen on which the above description is based was collected by A.J. Dartnall and T. Sward on 29th March, 1977. It was taken off Kettering in D'Entrecasteaux Channel, 147°16'E, 43°8'S, at a depth of about nine metres and occurred on a bottom of muddy sand and broken shells.

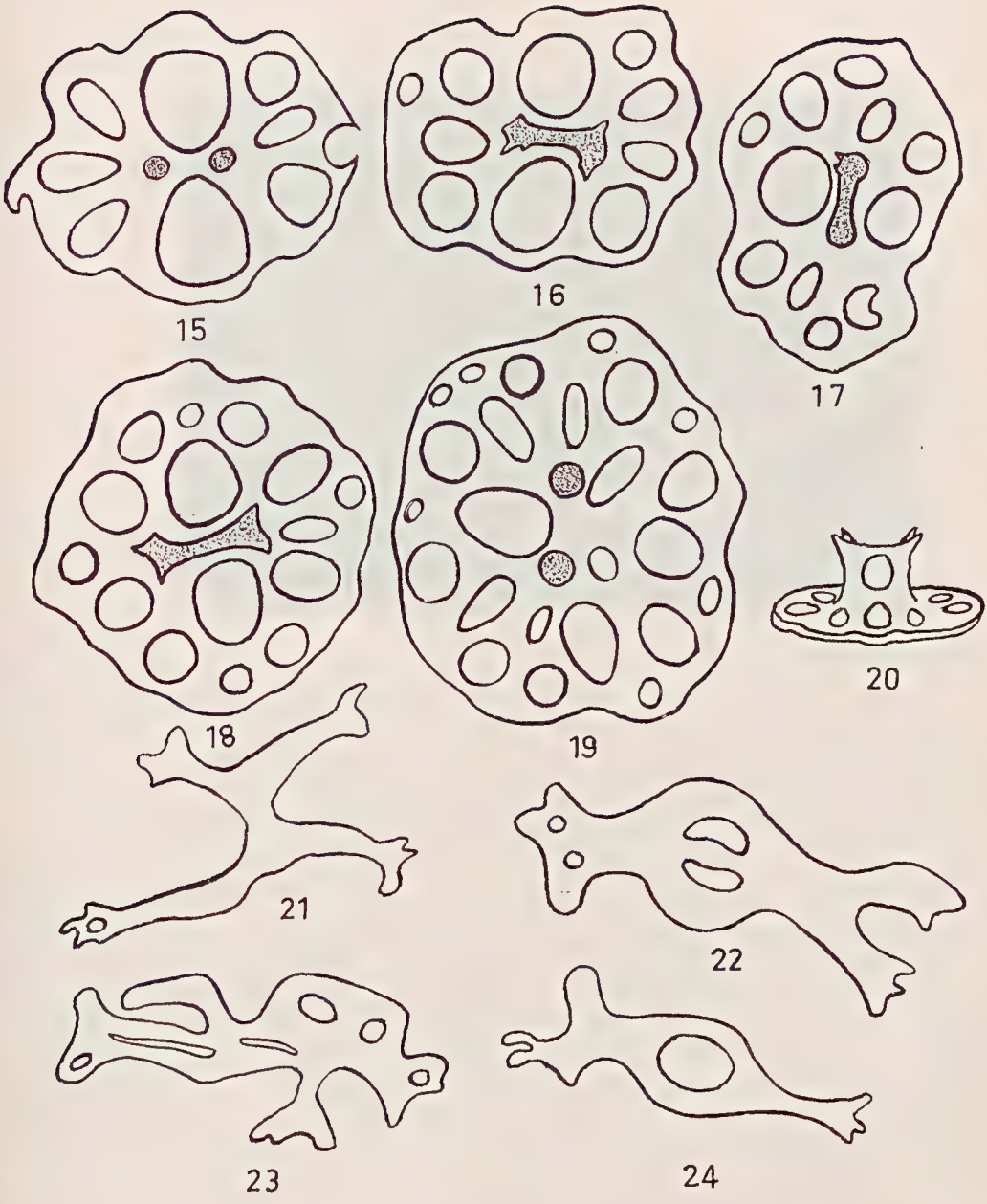
Remarks: In specimens of *N. dearmatum* from New Zealand Mortensen (1925) and Pawson (1970) found calcareous particles at anterior and posterior ends of the body. Mortensen also found them in the tentacles. The single Tasmanian specimen examined had no calcareous particles in the tentacles or at the posterior end of the body, except those in the anal papillae. Until a much larger number of specimens is examined, it does not seem advisable to regard the Tasmanian holothurian as a different species.

Family CAUDINIDAE

Paracaudina luticola Hickman, 1962
Paracaudina luticola Pawson, 1977

The original record of *Paracaudina luticola* Hickman (1962) was based on seven caudal extremities or "tails" dredged in Ralphs Bay, Derwent Estuary, on 30th June, 1959. The following description is based on two complete specimens from the same locality.

The body (plate 2) is elongate, fusiform and slightly curved. When fully extended it measures 160 mm long and 15 mm in greatest width. The introvert is about 19.0 mm long and 9.0 mm in width. Posteriorly the body tapers into a long slender caudal extremity, which forms about 7/16 of the total length. In the living specimen the body



FIGS 15 - 24. - *Neothyonidium dearmatum* (Dendy and Hindle); calcareous particles. 15 - 20 from the introvert, 21 - 24 from anal papillae.

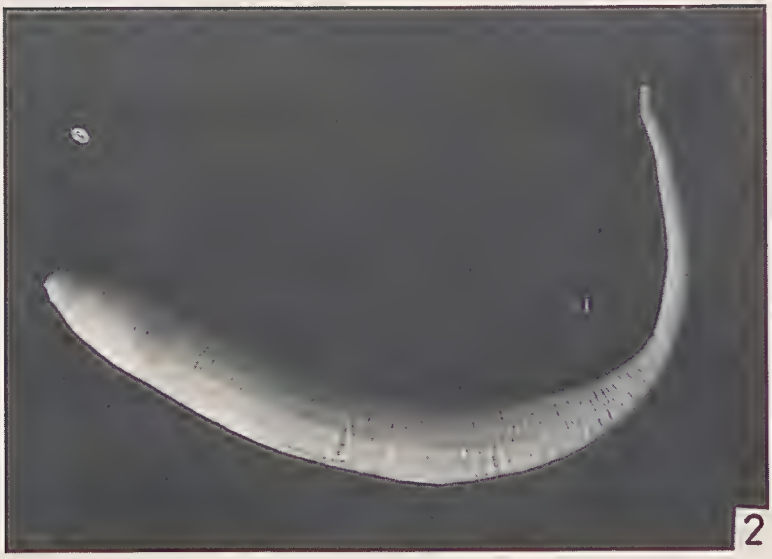
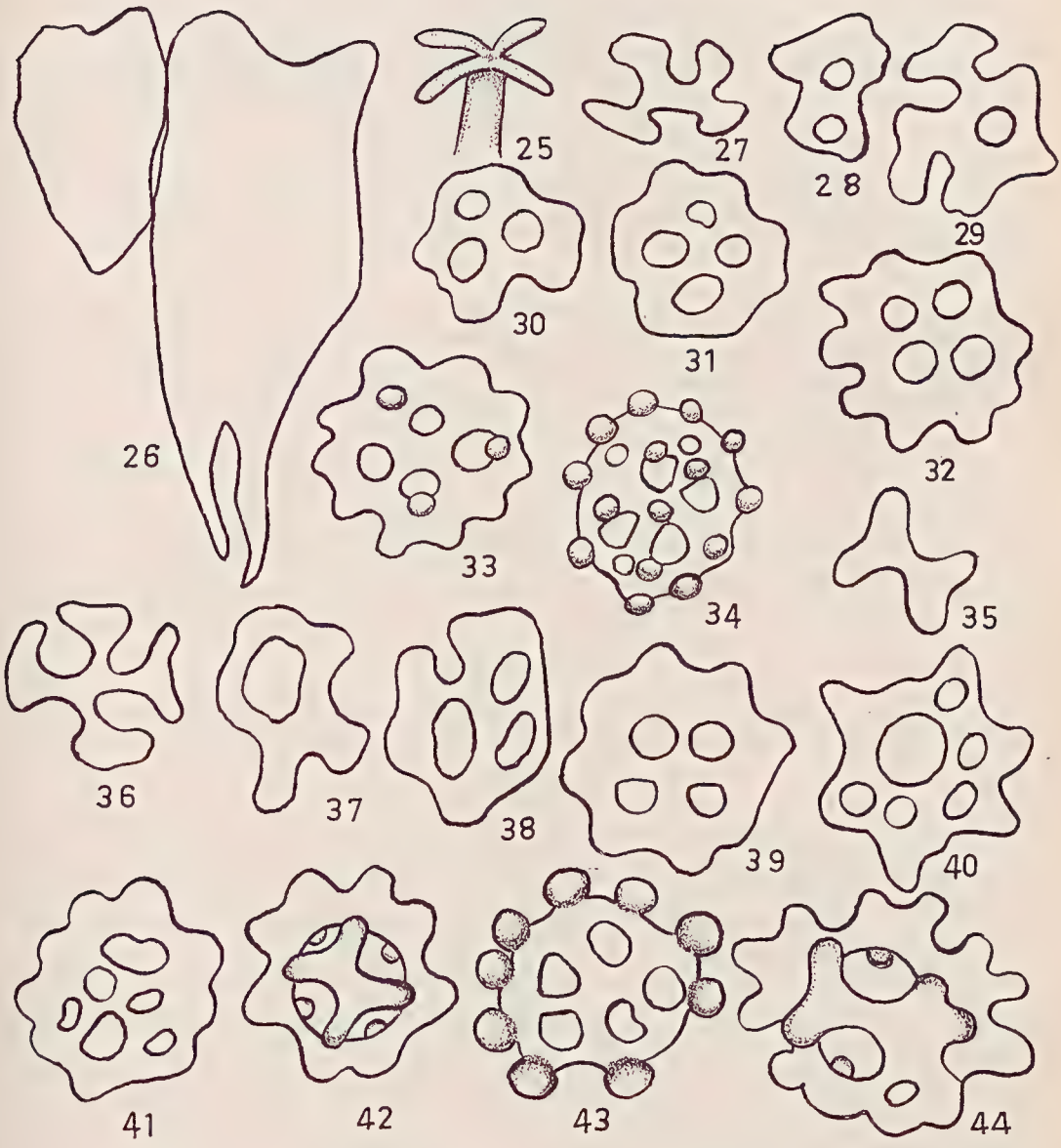


PLATE 2. - *Paracaudina luticola* Hickman extended.

does not taper abruptly to form the tail. When contracted the holothurian measures 68 mm long and 18 mm wide.

In life the colour is greyish but fades to white in preserved specimens. Muscle bands show faintly through the skin. The mouth is surrounded by 15 short tentacles, each having four finger-like lobes (text-fig. 25). Internally the tentacles form large elongate ampullae. The calcareous ring has five radial and five interradial ossicles of the form shown in text-fig. 26. The radials are fused with the interradials and slightly more than twice their length. Radial muscles form ten longitudinal bands arranged in five pairs. The retractor muscles are short, their posterior ends being attached a little way behind the ring vessel. Respiratory trees are extensive but Cuvierian organs are absent. The gonad has about 120 tubules arising from the branched posterior end of the oviduct and situated in the anterior third of the body cavity. The tubules form two groups of about 60, one group on each side of the dorsal mesentery. The genital aperture is situated dorsally on a small conical papilla close behind the ring of tentacles.

Calcareous particles are numerous in the skin of the whole body, except that of the peristome and tentacles, from which they are absent. The form of the particles in the skin of the introvert (text figs 27-34) varies from small irregular plates to large somewhat circular discs about 50µm. in width and having four holes and nine marginal knobs. Other knobs are sometimes present on the surface of the disc. The maximum number of holes is six and of marginal knobs eleven. In the mid-body region the particles have the forms shown in text-figs 35-44. They reach a maximum size of 60µm. in width and do not differ very much from those of the introvert. The most numerous forms are about 57µm. in width, more or less circular, with four holes and ten marginal



FIGS 25 - 44. - *Paracaudina luticola* Hickman; 25 tentacle, 26 a radial and an interradial ossicle; 27-34 calcareous particles from introvert, 35-44 from mid-body region.

knobs. Many crossed-cups (text-fig. 42) are also present. Calcareous particles of the caudal region have been described in a previous paper (Hickman 1962).

Locality: Ralphs Bay, Derwent Estuary, 147°27'E, 42°55'S, Tasmania. Two complete specimens collected at a depth of about 3.6 metres by R. Mawbey on 23rd April, 1975. The specimens were found while diving at night using a Hookah compressed air unit and an underwater light source. From observations made by the collector the holothurian lives in a sandy substrate, which is about 80 mm in depth and below which the sand is mingled with black organic material. In the case of one specimen only the "tail" was projecting from the sand, but in the other both "tail" and tentacles were showing, the rest of the body being hidden in the sand. An area of about 30-45 square metres was dug to a depth of about 150 mm without further specimens being found. The bottom was covered with scattered clusters of oysters. Other marine animals seen included sea-stars, flounders, flatheads and small transparent ascidians. Some red seaweed was floating in the water.

Remarks: *Paracaudina luticola* has some resemblance to *P. chilensis* (Muller). Pawson (1963) examined more than 400 specimens of the latter species from New Zealand waters and has given a full description of its features. *P. luticola* seems to differ in the following characters and habitat:-

(1) Its body does not taper "abruptly" as described by Pawson in the case of *P. chilensis*.
(2) The crossed-cup particles in its skin differ in not having a square plate on the inner side of the central hole and in possessing rounded knobs on surface and margin.
(3) It lives in a sheltered and shallow habitat at a depth of 3.6 - 13.0 metres, whereas *P. chilensis* occurs in more open and exposed situations at depths of 28-730 metres.

One of the two specimens of *P. luticola* found is lodged in the Australian Museum, Sydney.

ACKNOWLEDGEMENTS

My thanks are due to J.A. Dartnall, T. Sward, R. Mawbey and J.L. Hickman for help in collecting the holothurians and for the opportunity of examining them.

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A PLEISTOCENE SPINY ANTEATER FROM TASMANIA (MONOTREMATA: TACHYGLOSSIDAE, *ZAGLOSSUS*)

by Peter Murray
Tasmanian Museum, Hobart

(with two tables, 18 text-figures and two plates)

ABSTRACT

A partially articulated skeleton of a fossil *Zaglossus* from a cave located near Montagu, Tasmania, differs sufficiently from *Zaglossus bruijni* to warrant its assignment to another species. The Montagu specimen is probably conspecific with *"Echidna (Proechidna)" robusta* Dun, 1895 which includes the misnomer *"Ornithorhynchus maximus"* Dun 1895. The Montagu fossil is also conspecific with *Zaglossus harrissoni* Scott and Lord, 1921, from King Island Tasmania. *Echidna owenii* and *Echidna ramsayi* are suggested to be *nomina vana* because they are represented by undiagnostic fragments. Comparison of the cranium and certain postcranial elements of the Montagu *Zaglossus* with *Zaglossus bruijni* reflect possible differences in feeding behavior between the two species.

INTRODUCTION

Pleistocene echidnas belonging to the genus *Zaglossus* have been known since 1868 (Krefft 1868). Fragmentary remains of these animals have subsequently been recovered from swamp and cave deposits of every Australian state except the Northern Territory (Owen 1884; Wilkinson 1887; Glauert 1914; Scott and Lord 1921). A confused synonomy has resulted due to nomenclatural changes and a lack of systematic comparison of the material (table 1). Many more fragments of fossil echidnas are present in museum collections around Australia. Unfortunately, they have generated little interest and are not often reported in the literature. Abundant remains of the genus have been recovered from several recently excavated cave deposits in New South Wales, South Australia and Victoria (J. Hope, N. Pledge, T. Rich and E. Gill pers. comm.), and in New Guinea (J. Hope pers. comm.).

The recent acquisition of a nearly perfect cranium and associated major postcranial elements in partial articulation from a Tasmanian cave deposit provides the necessary material to initiate a reassessment of *Zaglossus* fossils. The following is a detailed description of the Montagu *Zaglossus* material (Z.2031, Z.2032, Tas. Mus.) with some accompanying tentative remarks on its affinity with the living *Zaglossus bruijni* and fossil *Zaglossus* specimens described in the literature.

MATERIALS

Specimens numbered Z2031 and Z2032 (Tasmanian Museum) have been assigned to *Zaglossus robusta* Dun, 1895 (figure 1) of which the following materials are described:

Cranium lacking mandibles and zygomatic arches; rostrum of second individual broken at level of groove for ascending facial vein; vertebrae: C 2-4, T 5-16 (?), L 1-2, S1; left and right humeri, left humerus of second individual; paired clavicles and episternum; left and right scapulae, right scapula of second individual; left and right femora; left and right fibulae; left and right tibiae, innominate bones lacking ilia.

A complete *Zaglossus bruijni* skeleton (M9852) was supplied by the Australian National Museum, Sydney. Two partially prepared skeletons in the C.S.I.R.O. collection,

TABLE 1

FOSSIL ECHIDNA REMAINS AS REPORTED IN THE LITERATURE

Species	Elements recovered	Locality	Age	Author
Echidna oweni=ramsayi	distal phalange	Darling Downs, Queensland[4]	Pleistocene	Dun, 1895
	distal phalange	Wellington Caves, N.S.W.[5]	Pleistocene	Dun, 1895
	distal humerus fragment[1]	Darling Downs, Queensland[6]	Pleistocene	Krefft, 1868
	scapula and episternum	Wellington Caves, N.S.W.[6]	Pleistocene	Dun, 1895
	femur	Wellington Caves, N.S.W.[6]	Pleistocene	Dun, 1895, Glauert, 1914
	humerus[2]	Wellington Caves, N.S.W.[6]	Pleistocene	Owen, 1884
Proechidna robusta	skull and atlas[3]	Gulgong, N.S.W.[5]	? Pliocene	Dun, 1895
(=Ornithorhynchus maximus)	humerus[3]	Gulgong, N.S.W.[5]	? Pliocene	Dun, 1895
Zaglossus hacketti	atlas[3]	Mammoth Caves, W.A.[7]	Pleistocene	Glauert, 1914
	clavicles and episternum			
	pelvic girdle			
	femora			
	tibia			
	radius			
Zaglossus harrissoni	femur and humerus fragment[3]	King Island, Tasmania[9]	Pleistocene	Scott and Lord, 1921
	femur	Scotchtown Cave, Tasmania[9]	Pleistocene	Murray (unpublished)
Zaglossus (Z2031-2)	skull	Montagu Caves, Tasmania[8]	Pleistocene	Murray and Goede, 1976
	vertebrae			
	innominate			
	humeri			
	scapulae			
	clavicles and episternum			
	femora			
	tibia			
	fibulae			
Tachyglossus sp.	femur	Wellington Caves[6]	Pleistocene	Dun, 1895
	humerus	Mammoth Caves[7]	Pleistocene	Glauert, 1910
	"armbone"	Darling Downs, Queensland[10]	Pleistocene	Dun, 1895
	element unknown	Mowbray Swamp, Tas.[10]	Pleistocene	Gill and Banks, 1956
	element unknown	Scotchtown Cave, Tas.[10]	Pleistocene	Gill and Banks, 1956

1. Type *E. oweni*
2. Type *E. ramsayi*
3. Type for species given
4. Queensland Museum, Brisbane
5. Mining and Geological Museum, Sydney
6. Australian National Museum, Sydney
7. Western Australian Museum and Art Gallery
8. Department of Anatomy, University of Tasmania
9. Queen Victoria Museum, Launceston
10. Location unknown.

Canberra were also examined. This material was supplemented by reference to Gervais (1878). Measurements of a series of *Z. bruijni* skulls were kindly taken for me by Dr. L. Weller (Department of Anatomy, University of Tasmania) and Prof. J. Johnson (Dept. of Biophysics, Michigan State University), when they visited the American Museum of Natural History in 1976. Observations on muscular anatomy are based on dissections and dried muscle preparations of *Tachyglossus aculeatus setosus* prepared according to instructions given in Hildebrand (1968). A Powerline Model 72 speed engraver was found useful for removing hard, calcareous matrix from the skeleton.

LOCALITY, STRATIGRAPHY, ^{14}C DETERMINATION

A detailed description of the Montagu site is given in Murray and Goede (1977). The *Zaglossus* skeleton was recovered from a pocket within a steeply inclined shaft plugged by consolidated cave fill. The pocket also contained a complete pair of mandibles, a femur, a tibia and paired innominates of *Sthenurus* aff. *occidentalis*. *Thylacoleo carnifex*, *Protemnodon anak*, *Zygomaturus* (?) and *Palorchestes* sp. were recovered from stratigraphically equivalent positions within the cave. The fauna closely resembles other Australian Late Quaternary fossil assemblages. The fauna was contained within the uppermost of three strata of cave sediments. Bone collagen from this stratum (Bed 3B) yielded a ^{14}C determination of 10,000±700 (R5001/2) radiocarbon years. The date is considered a minimum age. However, geomorphological evidence also suggests that the deposit may postdate the maximum cold phase of the last glaciation. Dominance of solution weathering products within Bed 3B implies a less cold climate and greater abundance of moisture that followed a cold period denoted by a predominance of angular (frost-fractured) products in Bed 2.

SYSTEMATICS

Subclass PROTOTHERIA
Order MONOTREMATA
Family TACHYGLOSSIDAE
Zaglossus robusta Dun, 1895

1868 *Echidna owenii* Krefft, *Ann. Mag. Nat. Hist.*, 4(1), 113, 114; figures 1-3. *(Nomen vanum)*.
1884 *Echidna ramsayi* Owen, *Phil. Trans. R. Soc.*, 175, 273-5, Pl. 14, figures 1-3. *(Nomen vanum)*.
1895 *Echidna (Proechidna) robusta* Dun, *Rec. Geol. Surv. N.S.W.*, 4, 121-3, Pl. 11, Figures 5, 6, Pl. 12.
1895 *Ornithorhynchus maximus* Dun, *Rec. Geol. Surv. N.S.W.*, 4, 123-5, Pl. 11, Figures 1-4.
1921 *Zaglossus harrissoni* Scott and Lord, *Pap. Proc. R. Soc. Tasm.*, 13-15, Pl. 5.

Holotype - Cranial fragment, Australian Museum no. F.51451; atlas vertebra, F. 51452 and a right humerus *("Ornithorhynchus maximus")*, F.51453. *Echidna owenii* and *Echidna ramsayi* are considered *nomina vana* in the sense given by Simpson (1945, p.30; 1948, p.31) and subsequently employed by Welles and Gregg (1971, p.6). Both species designations are based on fragmentary remains of humeri. *Echidna owenii* consists of a fragment of distal articular surface and is undiagnostic at the species level. *Echidna ramsayi* is based on more complete but inadequate material for species assignment. *Echidna owenii* and E. *ramsayi* are therefore validly established names that may apply only to these type specimens.

Type Locality - Auriferous drift in a limestone cavern entered via the Canadian Lead mine shaft, Gulgong Gold Field, N.S.W.
Age - Considered to be Pliocene.
Referred Specimens - Right femur *(Zaglossus harrisoni* Scott and Lord 1921), (1965:39:

TABLE 2

METRIC ATTRIBUTES (IN MM) OF SKULLS OF *ZAGLOSSUS BRUIJNI* EMPLOYED IN SCATTER DIAGRAMS

	A	B	C	D
AMNH 194702	154.0	130.9	96.1	13.4
AMNH 195370	-	136.2	105.3	16.8
AMNH 190862	186.0	160.5	118.0	16.2
AMNH 190863	193.0	164.9	123.5	17.7
AMNH 195369	-	148.8	107.4	16.2
AMNH 195371	-	151.8	113.0	16.3
AMNH 195372	-	156.2	117.4	16.4
AMNH 195373	-	-	123.8	16.7
AMNH 66194	168.0	145.5	108.7	14.0
AMNH 104020	-	154.2	108.6	14.8
AMNH 157072	158.0	135.1	97.2	14.5
AMNH 110047	-	121.7	-	17.0
AMNH 157073	-	130.2	92.9	16.0
AMNH 190861	-	181.9	131.5	17.9
AMNH 190860	-	-	123.6	16.6
Aust. Mus. M9852	141.2	120.0	86.0	12.0
Tas. Mus. Z2031*	165.0	139.0	95.5	21.6

A. Condylobasal Length
B. Palatal Length.
C. Rostrum Length.
D. Rostrum Width.

CALCULATIONS PERTAINING TO ROSTRAL DECURVATION

	E	F
Tas. Mus. Z2031	264.3	30.0
Aust. Mus. M9852	121.5	57.6
Gervais-1	223.5	42.2
Gervais-2	170.0	50.0
AMNH 195369	184.6	47.3
AMNH 190863	185.8	52.7
AMNH 190862	222.2	42.4
AMNH 195370	164.1	49.0
AMNH 194702	187.8	40.8
AMNH 190861	245.1	43.6
AMNH 157073	169.5	45.2
AMNH 157072	197.4	40.0
AMNH 195372	227.9	40.1
AMNH 104020	249.0	36.0
AMNH 66194	239.8	35.3
AMNH 195371	195.9	45.6
Harvard Mus. 12414	263.0	33.1

Gervais-1 and 2 measured from natural sized lithographs after Gervais (1878).
E. Radius (mm)
F. Degrees subtending θ

5/Q.V.M. 13), fragment of rostrum, (Z2032), Montagu Caves, Northwestern Tasmania; nearly complete cranium and associated postcranial elements described herein (Z2031), Montagu Caves.

Fragmentary remains of a second individual were recovered from an adjacent, unconnected cave system. These include a rostrum fragment, a humerus fragment and a scapula. The specimen was associated with a predominantly modern fauna. A single *Sthenurus* upper molar suggests a pre-Holocene date for the deposit.

With the possible exception of *Zaglossus "Proechidna" robusta* Dun, all reported *Zaglossus* ("Echidna", "Proechidna") fossils date from the Quaternary (Bartholomai 1972, 1975; Tedford 1966). Dun (1895, p.120) considered *Proechidna robusta* to be from Pliocene auriferous drift. However, it is possible that the Canadian Lead faunal deposit is contemporary with nearby Wellington Caves breccia.

Tachyglossus remains appear to be less common than *Zaglossus* in Pleistocene sites even though the former is frequently found in Holocene cave and dune deposits. At least some Pleistocene *Tachyglossus* fossils are larger than the living *T. aculeatus* (Glauert 1910). *Zaglossus* and *Tachyglossus* remains occur in the same deposits suggesting that they were sympatric during the Pleistocene. Van Deusen and George (1969, p.13-14) consider the two genera to be allopatric in New Guinea where *Tachyglossus* prefers drier, more open forest habitats.

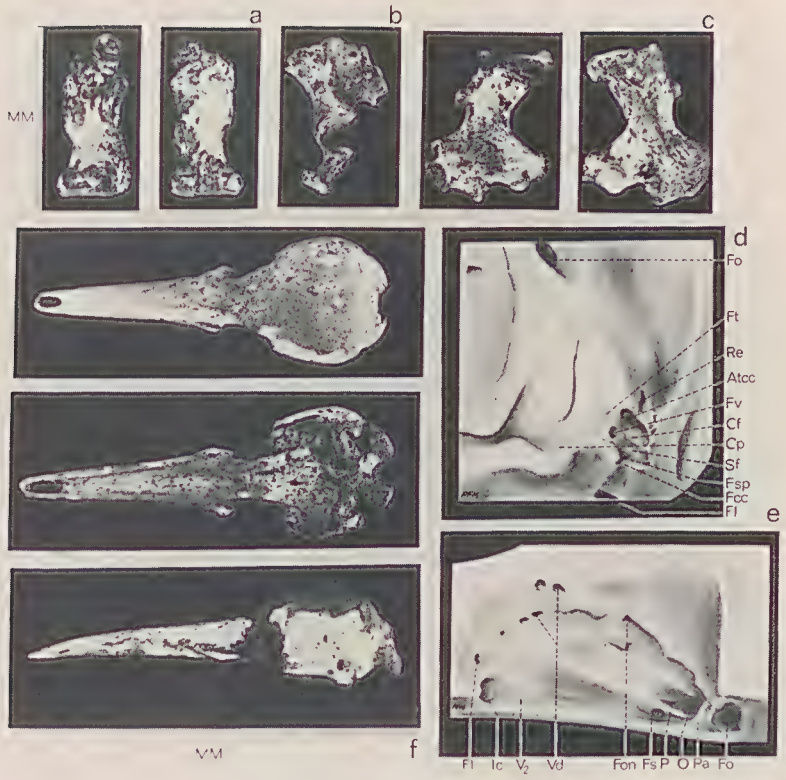

PLATE 1. - Fossil remains of Z2031 -32; a, posterior and anterior aspects of left femur; b, left scapula (Z2032); c, right humerus; d, drawing of the ear region; e, drawing of the orbit; f, dorsal, palatal and lateral aspects of cranium; Fo, foramen pseudovale; Ft, tympanic fossa; Re, recessus epitympanicaus; Atcc, apertura tympanica canalis facialis; Fv, vestibular foramen; Cf, crista facialis; Cp, crista parotica; Sf, sulcus facialis; Fsp, foramen stylomastoideum primitivum; Fcc, Foramen into canalis craniotympanalis; Fj, jugular foramen; Fl, lacrimal foramen; Ic, infraorbital canal; V_2, groove for maxillary nerve; Vd, diploic veins; Fon, orbitonasal foramen; Fs, sphenopalatine foramen; P, foramen pterygoid canal; Pa, palatine.

DESCRIPTION

Cranium (Table 2; Figs 3-5; Plate 1; Appendix)

The terminology applied to the descriptive anatomy of the fossil cranium is derived from Tandler (1902) and Kuhn (1971); the ear region follows Simpson (1938).

Neurocranium

The braincase is large and globular with a slight flattening of the supraoccipital. The maximum width of the neurocranium is located immediately anterior to

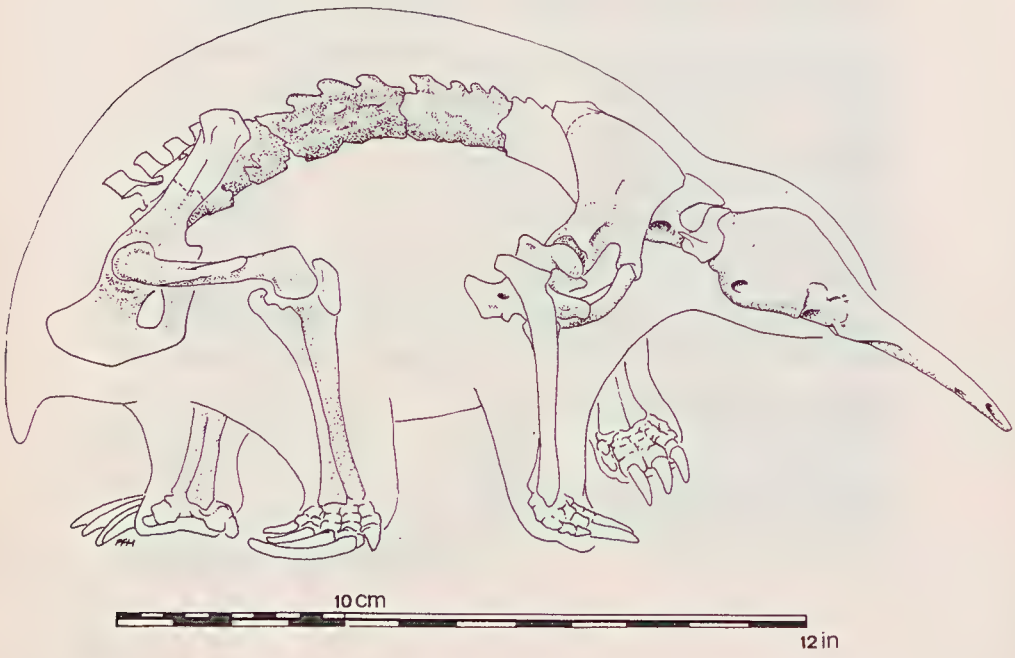

FIG. 1. - Restoration of the skeleton of *Zaglossus robusta* (Tas. Mus. Z2031) from Montagu, Tasmania. Recovered elements are stippled.

the temporal foramina. The cranial bones are thin and internally bear the impressions of the sulci and gyri of the brain. The sutures are obliterated throughout. The anterior portion of the neurocranium grades smoothly into an elongated rostrum. Low, rounded crests arch across the braincase. These are the anterior nuchal line representing the trapezius anterior muscle and the posterior line for the m. rhomboideus cervicis. The anterior (superior) nuchal line extends from the superoposterior edge of the orbit to the midline, terminating at the approximate area of the occipitoparietal junction. The posterior nuchal line describes a more transverse arc across the squamosal to merge with the anterior line. The inferior nuchal line for the attachment of semispinalis capitus and complexus major muscles is indistinct. The supraoccipital bone presents a broad, smooth surface for the attachment of the rectus capitus dorsalis major and minor muscles.

A shallow, circular pit is present in the supraoccipital immediately superior to

the foramen magnum. The superomedial aspect of the occipital condyles are bounded by a pair of shallow triangular depressions. The occipital condyles are large, elongated, somewhat rectangular articular surfaces with the long axis diverging from the horizontal at approximately 43 degrees. The condyles bulge prominently at the back of the neurocranium. The supra and exoccipital bones are produced outwards around the foramen magnum.

The foramen magnum is rectangular in shape. Large temporal foramina for the diploic arteries are located within a shallow depression formed by the squamosal. The squamosal itself is thin and high. Inferiorly, it defines a deep posterior temporal fossa.

Rostrum

The rostrum is very broad, moderately elongated and gently decurved. The distal termination is blunt, rounded and thin dorsoventrally. The entire structure is moderately compressed. The rostrum gradually increases in width to the level of the infraorbital foramen. At this point it is broadly connected to the braincase. A shallow depression occupies the midline in the position of the median suture of the frontal bones. It extends anteriorly to the approximate position of the nasofrontal junction. The perimeter of this area is perforated by numerous, small foramina. A faint median groove continues from the nasofrontal depression to the posterior margin of the opening of the external nares. The aperture for the external nares is an elongated, oval fenestra, slightly widened anteriorly.

FIG. 2. - Map showing some of the localities from which *Zaglossus* fossils have been recovered. Hatchures denote the present range of *Zaglossus bruijni*. M, Montagu Caves; S, Scotchtown Cave, located in northwestern Tasmania.

The premaxillary suture is open. Large, elongated maxillofacial foramina are located on the lateral and inferolateral margins of the rostrum near the base of the nasal aperture and more posteriorly to a point about two-fifths of the distance to the infraorbital canal.

Orbit (Plate 1e)

The shallow orbit has an irregular but definable superior border penetrated by several large foramina for the diploic veins. A low triangular protuberance on the mid-superior border serves for the attachment of the fiberous aponeurosis of the anterior temporalis muscle. The large infraorbital canal is located at the internal angle of the root of the maxillary process of the zygomatic arch. The optic fissure is subdivided by a pair of low crests which separate the opthalmic nerve from nerves II, III, IV and VI superiorly and the maxillary division of the trigeminal inferiorly. A small sphenopalatine foramen located anterior to the optic fissure receives branches from the infraorbital artery and nerve. The foramen of the pterygoid canal pierces a process of the palatine bone which separates the optic fissure from foramen pseudovale. Foramen pseudovale (V_3) is relatively large and circular in shape. The superior

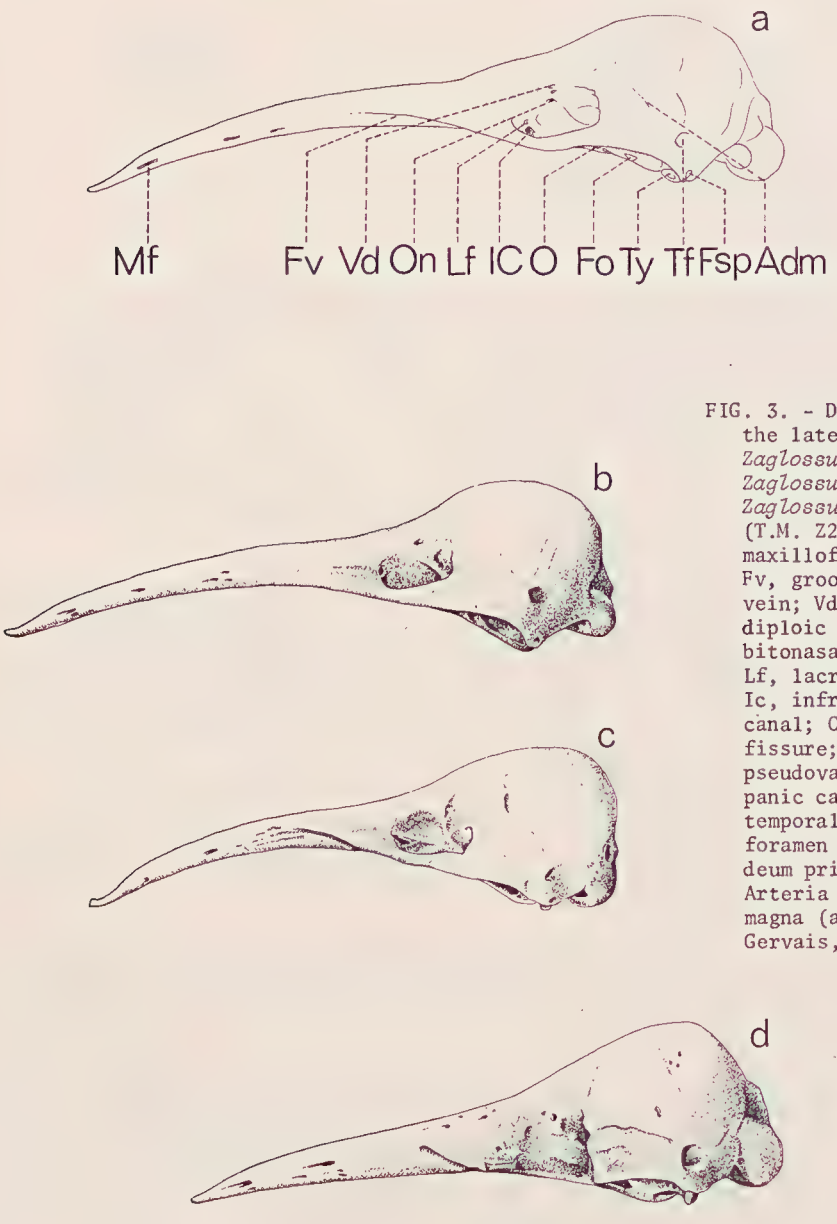

FIG. 3. - Drawings of the lateral aspect of *Zaglossus* skulls. a-c, *Zaglossus bruijni;* d, *Zaglossus robusta* (T.M. Z2031); Mf, maxillofacial foramen; Fv, groove for facial vein; Vd, foramen for diploic vein; On, orbitonasal foramen, Lf, lacrimal foramen; Ic, infraorbital canal; O, orbital fissure; Fo, Foramen pseudovale; Ty, tympanic cavity; Tf, temporal foramen; Sp, foramen stylomastoideum primitivum; adm, Arteria diploica magna (a, b, after Gervais, 1878).

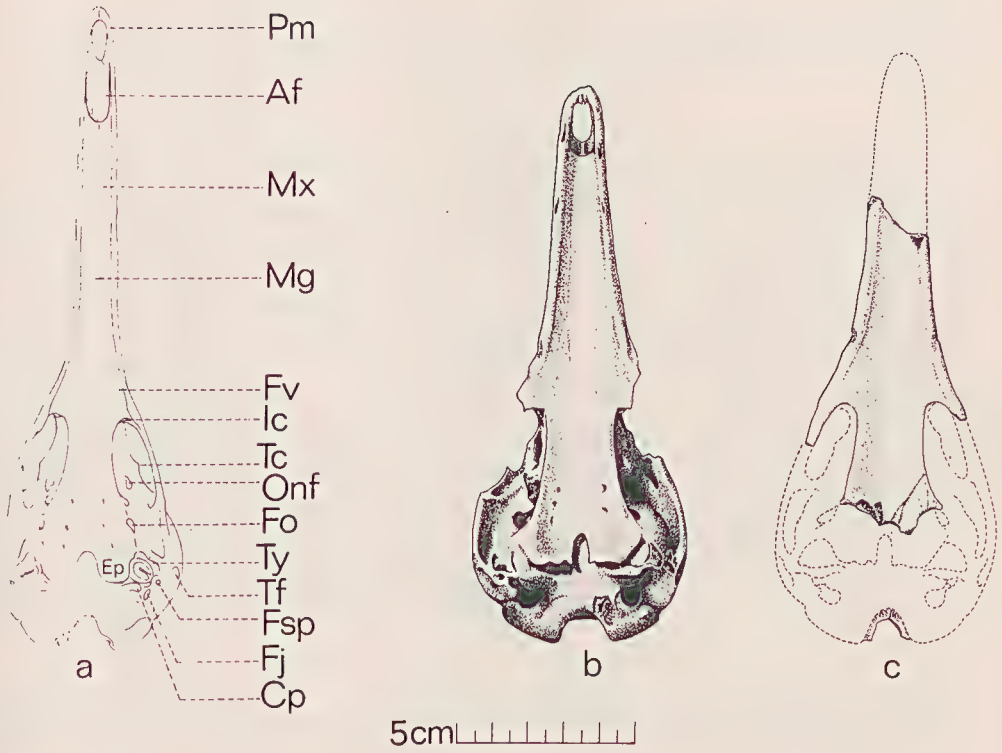

FIG. 4. - Drawings of the palatal aspect of Zaglossus skulls. a, *Zaglossus bruijni;* b, *Zaglossus robusta* (T.M. Z2031), c, *Zaglossus "Proechidna" robusta;* Pm, premaxilla; Af, anterior palatine fenestra; Mx, maxilla, Mg, median groove; Ic, infra-orbital canal; Tc, temporalis crest; Onf, orbitonasal foramen; Fo, Foramen pseudovale; Ty, tympanic cavity; Tf, Temporal foramen or canal; Fsp, foramen stylomastoideum primitivum; Fj, jugular foramen; Cp, crista parotica (c, after Dunn 1895).

portion of the optic fissure continues anteroposteriorly as a shallow groove. This groove terminates in a small orbitonasal foramen that transmits V_1.

The base of the orbit is bounded inferiorly by the lateral edge of the palatine bone. Superior to this crisply defined edge is a sill-like expansion of the orbital wall that transmits the infraorbital nerve and artery to the opening of the canal.

Ear region (Plate 1d)

The small, shallow, triangular tympanic cavity is tilted backwards relative to the horizontal plane of the skull. The posteroinferior border of the squamosal forms one side of a deep, crescent-shaped depression for the origin of the detrahens mandibulae muscle. The area immediately anterolateral to the tympanic cavity is markedly inflated. The posteroexternal edge of the swollen petrosal merges with the posterior

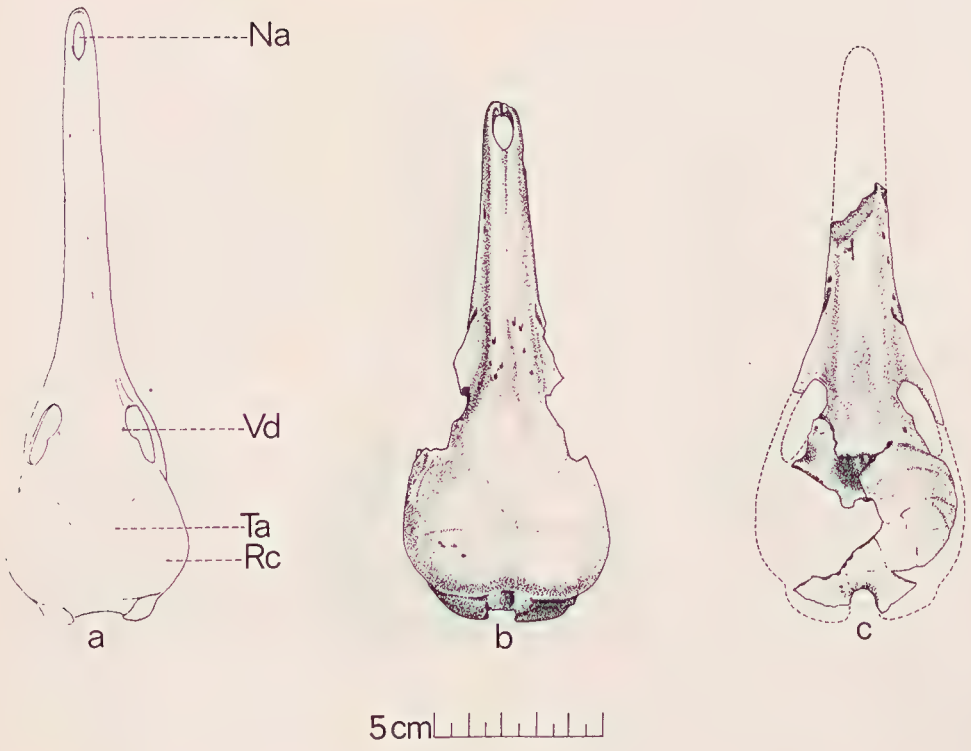

FIG. 5. - Dorsal Aspect of Zaglossus skulls. a, *Zaglossus bruijni;* b, *Zaglossus robusta* (T.M. Z2031); c, *Zaglossus robusta;* Vd, diploic vein; Ta, trapezius anterior crest; Rc, Rhomboideus cervicis crest (c, after Dun 1895).

edge of the squamosal defining the lateral side of the tympanic cavity. The posterior border of the tympanic cavity consists of a low, narrow crest composed of the crista parotica (paroccipital process) and its lateral extension, the processus hyoideus. The hyoid process forms the ventral arch of the posteriorly directed foramen stylomastoideum primitivum. A shallow notch divides the more delicate processus hyoideus from the crista parotica. The medial border of the tympanic cavity is formed by the lateral edge of the epipterygoid. The relatively small, triangular tympanic cavity is very shallow, deeper posteriorly than anteriorly, and is defined from the petrosal by a faint marginal crest anteromedially and anterolaterally. The epipterygoids form a low, rounded margin having no appreciable lateral overhang.

The posteromedial border of the cavity opens into a canal formed by an overhang of the posterolateral edge of the epipterygoid and crista parotica, the "tuba eustachii ossea" of Gaupp (vascular canal of Simpson, 1938).

The shallow, narrow recessus epitympanicus extends anterosuperiorly to lie outside the lateral border of the tympanic cavity. The crista and sulcus facialis is well developed. The fissura petropterygoidea, usually located at the apex of the tympanic

cavity, is absent. A median vascular groove extends from the base of the parotic crest to the anterior border (apex) of the cavity. This terminates in a small foramen (visible on one side only) representing the structure Simpson (1938, p.4) termed "dubious canals". The tympanic fossa is a round, shallow depression in the postero-lateral portion of the tympanic cavity. The apertura tympanica canalis facialis is relatively large and lies superficial to the lateral margin of the ear.

Palate

Suture lines in the basicranium and palate are entirely obliterated. The large jugular foramen is merged with a more posterior opening or "hypoglossal fenestra". Varying degrees of fenestration in the vicinity of foramina and elsewhere is a distinctive feature of modern *Tachyglossus* and *Zaglossus* skulls. The separation of the true jugular foramen from the hypoglossal fenestra is indicated by a hook-like process of the basioccipital. The thin basiphenoid is perforated by small foramina for the internal carotid arteries. The posterior margins of the epipterygoids are delicately notched and appear squarish in outline. A short, narrow "U"-shaped median palatal cleft divides the palatines and epipterygoids at the extreme posterior end of the palate. The palatine bones project posteriorly to cover the entire medial border of the epipterygoids. The paired epipterygoids and palatine bones form the posterior portion of a broad oval basin that continues anteriorly as the palatal arch. A series of small posterior palatine foramina pierce the palatine bones at the level of foramen pseudovale. These continue anteriorly to the level of the optic fissure. The palatines become narrowest slightly posterior to the root of the maxillary process of the malar. The palate is deeply arched at this point. The inferolateral surfaces of the malar roots display wide, shallow grooves that accommodate a large branch of the facial vein. An ascending branch of the facial vein is carried in a deep groove that lies anterior to the root of the malar along the side of the rostrum. It continues to course in an obliquely superior direction.

Three faint, transverse crests are visible in the roof of the deeply arched palate. The lateral margin of the palate is thick and rounded. These smooth edges appear to roll progressively inwards to the end of the rostrum. A rod-like nasal septum extends beyond the posterior border of the oval anterior palatine fenestra.

VERTEBRAL COLUMN

Axis (Plate 2e)

The axis is stoutly proportioned with a broad anteroposteriorly flared neural spine serving in part for the attachment of the rectus capitus dorsalis major muscles. The neural canal is nearly circular. The odontoid process is a short, wedge-shaped protuberance terminating in a pair of low crests. The anterior articular facets are broadly oval in outline. Their surfaces describe shallow arcs that grade superiorly into the neural lamina. The inferior borders of the articular surfaces extend inferiorly below the main body of the vertebra. The large circular transverse canals are located in the base of each relatively narrow, tapering transverse process. These open near the lower middle portion of the vertebral body. A deep, broad groove near the terminus of each transverse process indicates the attachment of the rectus capitus lateralis longus muscle.

Cervical Vertebrae (Plate 2e)

The remaining cervical vertebrae are represented by C 3-4. The neural spine of C3 is equal in height to that of the axis. The neural lamina are thin and narrow. The narrow, cylindrical neural spines of C3 and slightly shorter C4 project vertically. The neural canals are triangular in shape. The posteriorly swept transverse processes are broadly overlapped by the transverse process of the preceding vertebrae. Passages for the spinal nerves are completely bridged foramina located in the posterior portion of the base of each neural lamina. The centra of the cervical vertebrae are

PLATE 2. - Postcranial elements of Z2031. A, posterior and anterior aspects of right tibia; b, left fibula; c, clavicles and episternum (ventral); d, clavicles and episternum (dorsal); e, axis, C2-3; f, thoracic vertebrae 10-14; g, pelvic girdle (lateral); h, pelvic girdle (ventral); i, thoracic 15-16 and lumbar 1 vertebrae.

dorsoventrally compressed.

Thoracic Vertebrae (Plate 2f)

The thoracic vertebrae are in varying states of preservation. T5 has a low crest leading posteriorly to the neural spine. The broken neural spine base suggests

a low, caudally directed spine. There is a broad anterior extension of the neural arch bearing shallow notches anteriorly. The base of the centrum is incipiently rounded. A large foramen for the spinal nerves is present. The transverse processes are circular in section, as indicated by their broken bases. These probably represent small peg-like projections. The neural canal is nearly circular. A thin lamina bears an oval thickening on each side representing the prezygapophyses. The centrum has a deep, circular parapophysis on the lateral margin of each side.

T6-9 are poorly preserved. T10-14 are articulated fragments within a block of matrix. The more erect neural spines are somewhat hook-shaped and more robust than those of the preceding series. The bases of the prezygapophyses are stout and the crescentic articular surfaces are laterally directed. The centra are oval in outline. The neural canal is slightly more oval than round.

T15-16 are in articulation with L1. The last thoracic vertebra is missing the neural spine and arch. The neural spine of T15 is broader anteroposteriorly than any of the previous vertebra. The centrum and neural arch are both oval.

Lumbar Vertebrae (Plate 2i)

Lumbar 1 is represented by a centrum and a fragment of the right prezygapophysis. The centrum is oval; the body gently waisted. Well developed costal processes are present below the bases of the transverse processes.

Sacral Vertebrae

Sacral 1 is fused to the base of the ilia by its costal processes. The centrum is longer, deeper and more rounded than L1.

PECTORAL GIRDLE

Clavicles (Plate 2c, d)

The stout, moderately bowed clavicles are fused to the episternum. The distal articulations are damaged, but it is probable that the clavicles were relatively short. The attachment of the clavicles at the apex of the episternum creates an approximately 90 degree angle. The anterior surfaces of the clavicles are broad and roughened for the attachment of the trapezius and deltoid muscles. Each clavicle bears a deep, oval articular surface for the epicoracoids on the internal medial aspect. The left articular surface is broader and lies slightly lower than the right. The external or ventral surface of the clavicles are broad and flattened. They are triangular in section.

Episternum (Plate 2c, d)

The short, bell-shaped episternum displays a large, median (pectoralis) tubercle. The posterior side of the episternum is rugose. Articulation with the sternum is denoted by a shallow, concave, elliptical joint cavity.

SCAPULA (Plate 1b)

Description of the anatomical landmarks of the humerus and scapula is based on Jouffroy, Lessertisseur and Saban (1971), McKay (1895) and Wilson and McKay (1894).

The basically triangular, flat scapula becomes narrow and rounded immediately superior to the glenoid fossa. The inferior portion consists of a large glenoid fossa and a stout, oblique, posteriorly projecting coracoid process. The anterior edge of the blade is produced anteroinferiorly into a prominent acromion process. The inferior border of the acromion forms the upper edge of a large, semicircular, supraglenoid notch. The acromioclavicular joint surface is triangular and deeply concave. A broad flange of bone superior to the joint cavity represents the attachment of the acromiotrachelian muscle. The apex of the joint cavity is formed by two merging crests that

continue transversely across the medial supraspinous surface of the blade of the scapula forming a well-defined ridge for the attachment of the omohyoid muscle. The broad, flat area directly inferior to the omohyoid crest is occupied by the supraspinatus muscle. This region is traversed by a shallow vascular groove. The mesoscapular (spinous) border is rounded and relatively thick.

The robust coracoid process is rectangular in section. The coracoprocorocoid joint surface is broadly oval, concave superiorly and narrow and flat inferiorly. The glenoid fossa is wide, deep and "C"-shaped in outline. A strong supraglenoid tubercle for the proscapulohumeralis muscle lies above the glenoid fossa. The posteroexternal side of the scapula presents a convex, narrowly triangular surface for the attachment of the subscapularis muscle. A low, rounded crest defining the anterior border of this surface represents the origin of the long head of the triceps muscle. Anteriorly, a deep, broad fossa for the infraspinatus muscle is bounded by the spinous (anterior) border.

HUMERUS (Plate 1c)

Powerful forelimb musculature is expressed by the stout, widely flaring epicondyles and tuberosities of the short, flat humeri. There is considerable torsion between the plane of the tuberosites and head; a difference amounting to approximately 50 degrees. The posterior surface of the diaphysis is nearly flat. A low crest for the triceps muscle extends from the inferior tubercle of the entotuberosity (lesser tuberosity) to the ectepicondyle. The triceps scar consists of low, complex ridges and reticulations over much of the posterior surface of the shaft. The round entepicondylar foramen is positioned centrally near the base of the entepicondyle. The opening is smaller on the dorsal aspect. A prominent ridge extends from below the midregion of the humeral head to become the sharply defined external dorsal border of the shaft and leading edge of the ectepicondyle. The concavity produced by this deeply concave external border is occupied by the brachialis muscle.

The entotuberosity is developed into a stout crest having tubercles on its superior and inferior extremities. The superior tubercle for the insertion of the coracobrachialis muscle is largest of the two. The smaller, inferior tubercle takes the insertion of M. teres major. The broad entepicondyle is strongly crested for the origin of the flexor muscles. It is deeper and more robust than the ectepicondyle. Below the entepicondylar foramen, a broad, shallow excavation represents the origin of the flexor digitorum communis muscle.

The capitulum is narrow and rounded dorsally. Distally, it becomes constricted, then expands laterally and superiorly into a kidney-shaped surface on the anteroventral side. The anterior opening of the entepicondylar foramen consists of a large circular depression continuing posteromedially into a canal of much smaller dimensions.

The anterior border of the humerus is a prominent crest extending from the middle of the anterior surface of the entepicondyle to the ectotuberosity. It flares into a broad deltoid crest immediately inferior to the ectotuberosity. The distal portion of the ectotuberosity is missing on both humeri.

The medial (internal) surface consists of a broad, shallow depression for the coraco-brachialis superficialis muscle. This accentuates the lower portion of the anterior crest and extends its lower border to the extremity of the entepiocondylar crest. The extremity of the ectepicondyle is missing on both humeri. A narrow, rounded ridge for the attachment of flexor carpi radialis is situated directly inferior to the entepicondylar depression. A wide intercondylar notch is defined laterally by the capitulum and medially by the flexor carpi radialis tubercle.

Between the tuberosities, immediately inferior to the head, a deep, broad, lunate

depression denotes the attachment of the coracobrachialis profundus and supracoracoideus muscles.

The crescentic humeral head projects dorsally beyond the surface of the diaphysis. Medially, the head is merely a thickening in the center of the tuberosities.

INNOMINATE (Plate 2g, h)

The ilia are missing from the innominate bones. The pelvic inlet is high and narrow. Large fenestrae perforate the oval acetabulae. The ischia are long and broad with high, rounded tuberosities. Together, the tuberosities form a "U"-shaped notch ventrally at the ischio-pubic juncture. The long pubic symphysis is marked by a substantial crest for the attachment of the rectus abdominus aponeurosis and an apparently very broad gracilis muscle. Deep, elliptical joint cavities for the epipubic bones extend from the midline of the anterior face of the pubis to approximately a third of the distance to the anterior inferior iliac spine. The pectineal (pubic) tubercle is rounded and prominent. A thick crest on the anterior border of the acetabulum represents the origin of the rectus femoris muscle. The base of the ilium is triangular in cross-section. The ventral surface of the ilium is shallowly excavated to accommodate the iliacus muscle. A deep semilunar notch is formed by the projection of the inferior iliac spine below, and the ventral surface of the ilium superiorly. The depth of the notch is accentuated by the outline of the base of the first sacral vertebra.

FEMUR (Plate 1a)

The femur diaphysis is markedly compressed anteroposteriorly. The trochanters are torsioned slightly around the plane of the condyles to approximately 16 degrees. The neck is well developed. The greater trochanter is higher than the lesser and is more robust to the extent that it can be seen. The head of the femur is hemispherical, with a slight flattening in the area reserved for the fovea in Eutherians.

The flattened anterior surface of the femur shaft is marked by two shallow excavations on either side of a low, rounded central convexity. The greater trochanter continues inferiorly for approximately two-thirds of the length of the shaft in the form of a narrow crest. The crest grades into the shaft producing the upper limb of a smooth, concave profile that continues inferiorly to the prominently external projection of the lateral condyle. The medial border of the femur shaft is concavoconvex in profile. The medial condyle is disposed laterally so that the internal border of the shaft extends beyond a broad, flat surface for the attachment of the tibial collateral ligament.

The patellar surface is an elongated, narrow, nearly rectangular region defined superiorly by a transverse, shallow, elliptical depression. The articular surface of the medial condyle is slightly flattened inferiorly, becoming more sharply curved superiorly. The intercondylar notch is square and deep. The lateral condyle is moderately saddle-shaped on the inferior surface becoming more rounded superiorly.

The posterior surface of the lesser trochanter grades inferolaterally into a shallow, circular depression representing the attachment of the caudofemoralis muscle. Superiorly, there is a deeper, lunate depression for the insertion of the obturator externus muscle.

TIBIA (Plate 2a)

The tibiae are long and relatively slender. The proximal articular surface is broad and oval in outline. The distal end expands gradually from the base of the shaft into a relatively large articular surface. The medial malleolus is a robust,

conical process, rounded at its distal surface. It deviates gradually from the midline to a point nearly in line with the medial side of the proximal (condylar) articular expansion. In profile it is demarcated from the anterior surface of the tibia by a crest-like extension of the edge of the distal articular surface. The rounded, prominent tibial crest grades into the shaft at approximately one-third the distance to the distal articulation.

The origin of the tibialis anterior muscle is formed by a deep, triangular excavation having an arched, overhanging superior border. A less well developed depression medial to the tibial crest represents the origin of the extensor hallucis longus muscle. On the superoposterior surface of the shaft, a broad, rectangular muscle scar bounded medially by a prominent crest and terminating superiorly in a small conical tubercle, represents the attachment of the powerful popliteus (rotator fibulae) muscle. A thick crescentic muscle scar located immediately inferior to the rotator fibulae crest takes the insertion of the semitendinosus muscle. Distally, a deep, elongated, triangular sulcus accommodates the tendon and insertion of the tibialis posterior muscle. Part of the fibular head articulates with a narrow, rounded surface on the lateral aspect of the proximal end of the tibia. The articular surface for the medial condyle is larger than the lateral counterpart. The flattened surface is trapezoidal in outline. The posteromedial edge presents a slightly raised surface suggesting an intercondylar eminence. Medially, a shallow depression represents the attachment of the posterior cruciate ligament. A depression anteromedial to the edge of the medial condylar joint surface may represent the position of the anterior cruciate ligament. The lateral condylar surface is flat and kidney-shaped in outline. There is a fine, transitional crest between the lateral edge of this and the fibular articular surface. A shallow, transverse groove for the patellar ligament separates the condylar surface from the beginning of the tibial crest.

FIBULA (Plate 2b)

The fibulae are long, slender bones with a large, low profile articular surface and a high, hook-like flabelliform process. The shaft is nearly circular in section, save a moderate flattening of the external surface. The fibulae are slightly bowed anteroposteriorly.

The flabelliform process presents a rounded thickening at its summit. Between this and the articular surface is a small thin, blade-like prominence. A wide triangular excavation of the internal surface of the crest and its attachment to the shaft represents the insertion of the rotator fibulae muscle. The anteriorly directed conical protuberance on the flabelliform crest is for the attachment of the lateral patellar ligament. The internal surface and posterior border of the flabelliform process is roughened and crested for attachment of the flexor muscles. The proximal fibular articular head is a complex surface having two contact planes. It is trapezoidal in outline and wedge-shaped in section. The dorsal surface consists of a narrow, triangular surface for the external edge of the lateral condyle of the femur. The larger, internal surface articulates with the lateral tibial facet previously described.

An elongated depression halfway down the shaft represents the lower attachment of the rotator fibulae muscle. A deep, circular pit for the interosseous ligament is located on the anterior contact surface for the tibia. The distal articular surface is nearly circular in outline, shallowly concave and inclined posteriorly.

COMPARATIVE MORPHOLOGY

Cranium

Skulls of *Zaglossus bruijni* are longer, narrower and more delicately constructed

than Z2031. Specimens of *Zaglossus bruijni* may exceed the length of the known fossil forms by as much as 38 mm (Van Deusen and George, 1959). The most obvious differences pertain to the shape and dimensions of the rostrum and palate. The rostrum of *Zaglossus bruijni* is relatively longer, narrower and more strongly down-turned. This uniform curvature, measured from the posterior border of the epipterygoids to the inferior surface of the premaxilla, conforms to a nearly perfect arc that can be expressed in terms of the degrees of a segment of a circle (figures 6, 7). Measurements of a limited series suggests that the rostrum of *Z. bruijni* becomes less down-curved as the total length of the skull increases. The curvature of the rostrum in the fossil does not conform to a smooth arc and is more accurately described as an obtuse angle of 163 degrees with vertex at the infra-orbital canal. I have treated this as a simple arc in order to compare the specimen with *Z. bruijni*. Different allometric principles appear to be in operation between the two species. Calculations (table 2) imply that a specimen of *Z. bruijni* having the same length of rostrum as the fossil form would possess a more strongly down-curved beak. Similarly, a specimen of *Z. bruijni* having a rostrum and skull width comparable to the fossil form would possess an enormously long rostrum (figures 8,9, table 2).

The rostrum is pointed in *Z. bruijni* whereas the blunt proboscis of the fossil form agrees with *Tachyglossus*. Marked differences between the fossil form and *Z. bruijni* can be seen in the cross-sectional contour of the palate (figure 10). In *Z. bruijni*, the narrow palate resembles an inverted "V". The Montagu fossil

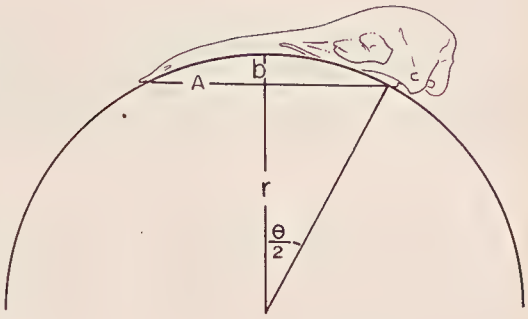

FIG. 6. - Method of determining rostral decurvation in *Zaglossus*. A= cord; b = interval between vertex of arc and cord; θ = subtending degrees of arc calculated as:

$$\theta = 2 \sin^{-1}\left(\frac{A}{2r}\right)$$

r = radius, calculated as:

$$r = \tfrac{1}{2}\left(b + \frac{\left(\frac{A^2}{2}\right)}{b}\right)$$

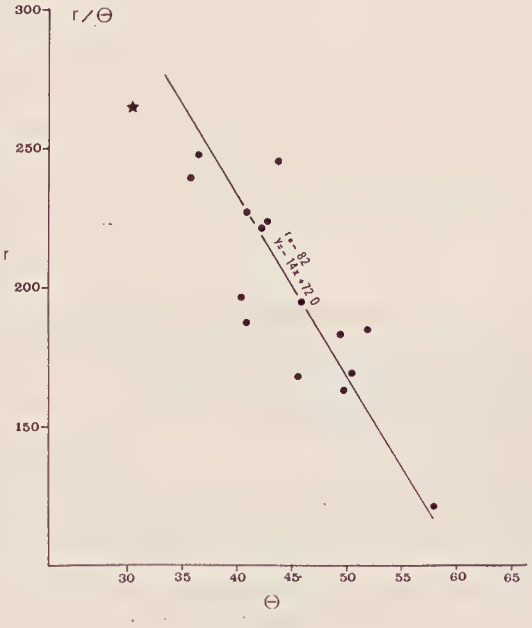

FIG. 7. - Scatter diagram plotting radius of curvature of the palate against degrees of arc subtending θ for *Z. bruijni* (dots) and *Zaglossus* sp. (T.M. Z2031); r, radius in millimetres; θ in degrees.

has an inverted "U"-shaped palatal section, relatively deeper, but similar to that of *Tachyglossus*.

Numerous foramina located near the base of the dorsal side of the rostrum are absent in *Zaglossus bruijni*. The nasal aperture is shorter and broader in the fossil than in *Z. bruijni*, and the premaxillary suture is open in the fossil but fused in the specimen in my possession. Perhaps age-related, the premaxillary suture is frequently open and mobile in *Tachyglossus aculeatus setosus*.

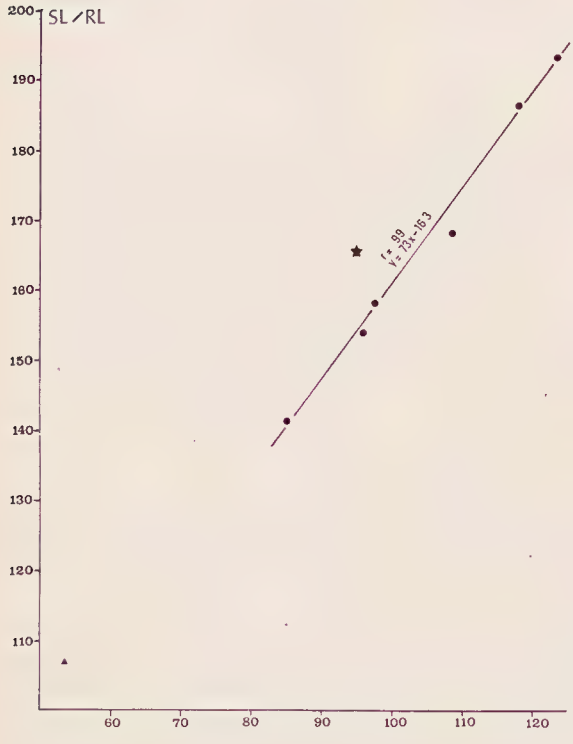

FIG. 8. - Scatter diagram plotting length of rostrum against condylobasal length of skulls of *Zaglossus bruijni* (dots), *Tachyglossus* (triangle), and *Zaglossus robusta* (T.M. Z2031)(star); scale in millimetres.

The overall size and shape of the braincase is similar in the fossil and *Zaglossus bruijni*. The braincase of *Tachyglossus* is relatively larger, broader and lower in proportion to the length of the rostrum. The fossil, *Tachyglossus* and *Zaglossus* share the tendency for varying degrees of fenestration of the skull.

The articular surfaces of the occipital condyles are broader in *Z. bruijni* than the fossil and *Tachyglossus* (fig. 11). Differences in the orbit are primarily proportional. The orbital walls in *Z. bruijni* converge towards the proportionally narrower palate to the extent that the entire orbital fissure is visible from a palatal view. In the fossil, full view of the optic foramen is obscured by the edge of the palate.

The ear regions differ in several respects. In the fossil form, the roof of the tympanic cavity is tilted backwards, relative to a horizontal plane drawn from the crista parotica to the tip of the rostrum (fig. 12). The roof of the cavity is horizontal in *Z. bruijni* and *Tachyglossus*. The tympanic cavity is also shallower and relatively smaller in the fossil than *Tachyglossus* and to a lesser extent *Zaglossus bruijni*. Unlike Z 2031, the tympanic recess is clearly defined in *Tachyglossus* and *Z. bruijni* by an extensive anteromedial overhang of the epipterygoids and an anterolateral crest of the squamosal (fig. 13). All three species show the characteristic triangular shape of the cavity. *Tachyglossus* and *Z. bruijni* lack the conspicuously swollen petrosal region that contributes to the obliquely displaced roof of the cavity in the fossil form. The recessus epitympanicus is enclosed by the lateral border of the tympanic cavity in both living forms. Other details of the ear region are similar.

The foramen stylomastoideum primitivum is directed laterally in *Z. bruijni* in contrast to the more posteriorly directed opening seen in the fossil and *Tachyglossus*. This difference in the orientation of the foramen is apparently due to a more

transversely directed processus hyoideus and more posterior disposition of the squamasol border in the fossil form. In *Z. bruijni* the inferior border of the squamosal commences medially in a gentle arc. In the fossil, and to a lesser extent in *Tachyglossus* it is sharply angled medially.

The posterior margins of the epiterygoids of the fossil appear considerably broader than in *Z. bruijni*. This is due to a continuation of the posterior palatine processes along the posterior epipterygoid margins (figure 14). The contact of the palatine processes and the epipterygoids is delineated by a shallow notch that contributes to the fluted appearance of the squarish posterior palatal margin. In *Z. bruijni* and *Tachyglossus* the notch is deeper and the palatine process is considerably shorter.

Proechidna robusta Dun, 1895, is very similar to the Montagu fossil echidna (figures 3-5). The Gulgong fossil is only slightly larger than the Montagu form and displays the same features of morphology that serve to differentiate the Montagu *Zaglossus* from *Z. bruijni*. These characteristics include the smoothly arched, deep palate, the broad dorsoventrally compressed rostrum, the morphology of the malar region in relation to the grooves for the facial veins, the presence of a large nasofrontal depression, and the overall proportions of the skull.

Dun (1895, p.122) estimated that the total length of the Gulgong skull fragment would have been on the order of 265 mm. If the Montagu specimen is used in the restoration, a figure of slightly more than 180 mm is obtained (figures 3-5, table 2). While this is within the maximum range of length in *Z. bruijni*, the relative proportions of the beaks of the fossils is more comparable to that of *Tachyglossus*.

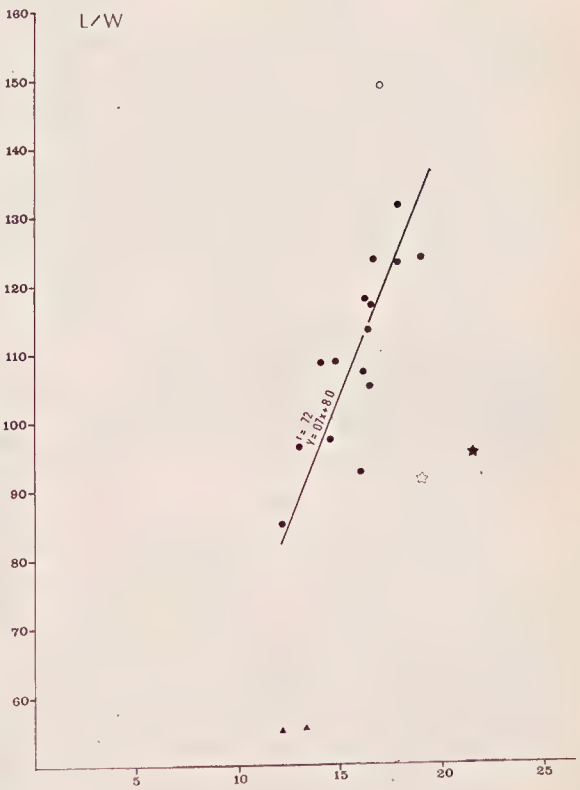

FIG. 9. - Scatter diagram plotting length against width of rostrum in *Zaglossus bruijni* (dots), *Tachyglossus* (triangles), and *Zaglossus robusta* (T.M. Z2031, 2032). Open symbols refer to damaged specimens.

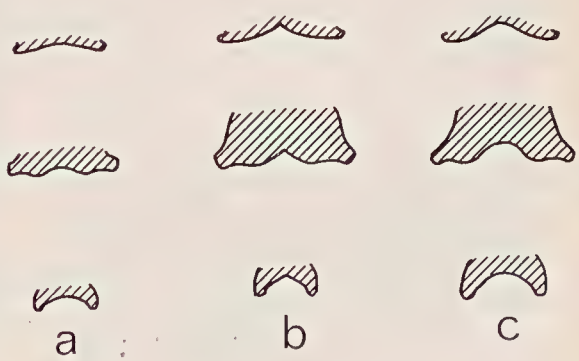

FIG. 10. - Cross-sections of the rostrum and palate of a, *Tachyglossus aculeatus;* b, *Zaglossus bruijni;* c, *Zaglossus robusta*. T.M. Z2031. Note the roof-shaped palatal arch of *Zaglossus bruijni*.

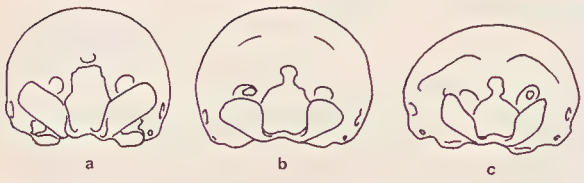

FIG. 11. - Comparison of the shape of the occipital condyles. (Drawings are scaled to equal sizes to facilitate comparison), a, *Zaglossus robusta* (T.M. Z2031); b. *Zaglossus bruijni* and c, *Tachyglossus aculeatus*.

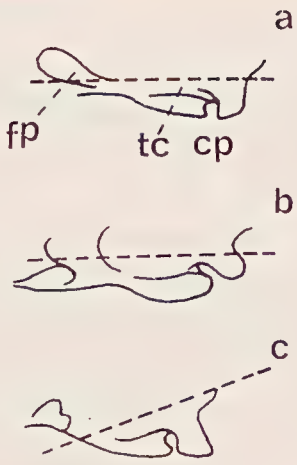

FIG. 12. - Lateral view of the ear region showing the angle of the petrosal (dotted line) which forms the roof of the tympanic cavity. a, *Zaglossus bruijni;* b. *Tachyglossus aculeatus* and *Zaglossus robusta* (T.M. Z2031). Fp, foramen pseudovale; Tc, tympanic cavity; Cp, crista parotica.

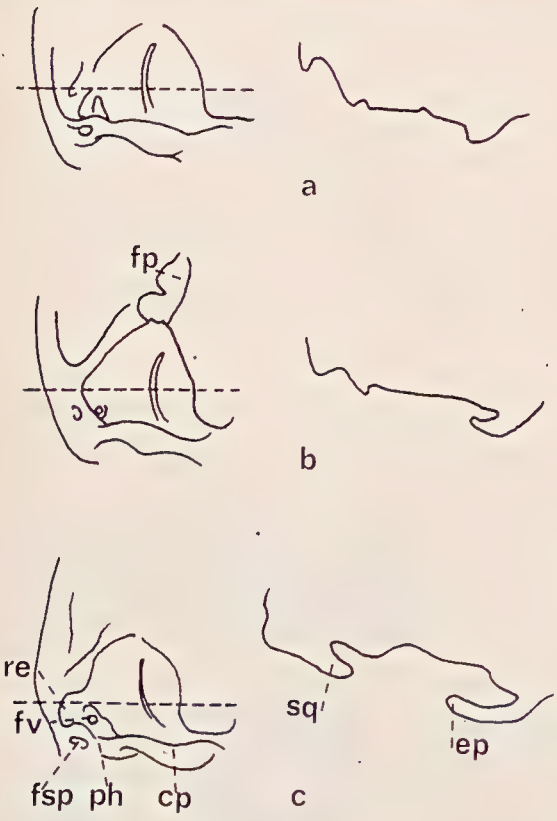

FIG. 13. - Comparison of the shape of the tympanic cavity in a, *Zaglossus robusta* (T.M. Z2031); b. *Zaglossus bruijni* (Aust. Mus. M9852) and c, *Tachyglossus aculeatus*, re, recessus epitympanicus; fv, vestibular foramen; fsp, foramen stylomastoideum primitivum; ph, processus hyoideus; cp, crista parotica; sq, squamosal; ep, epiterygoid (ectopterygoid).

Vertebral Column

The axis of the Montagu fossil differs from that of *Z. bruijni* in several aspects of morphology. The body of the vertebra of the fossil form is relatively broader and shorter. In living *Zaglossus* the dorsal aspect of the transverse process is markedly flared superiorly. This expansion is not expressed in the fossil axis, which is more like that of *Tachyglossus* (figure 15). The transverse canals of the fossil specimen are of moderate size and nearly round. They are large and irregularly oval in *Z. bruijni*. In the fossil, the articular facets for the axis are broader and less convex than in *Z. bruijni*. The neural canal is comparatively small in the fossil. The cervical vertebrae of the fossil form are more robust than those of *Z. bruijni*, having more prominent and heavy crests for muscle attachment. Slight differences in the morphology of the neural spines of the thoracic vertebrae are

apparent between the fossil and *Z. bruijni*. In the fossil they are stouter and may have been slightly more erect.

The remaining vertebrae are similar except for a difference in overall size. As many features of the vertebrae are subject to considerable variation, these specific morphological contrasts may be of little or no significance. The major difference that can be stated is that of increased size over *Z. bruijni*. Unfortunately, I have not been able to determine the exact number of vertebrae present.

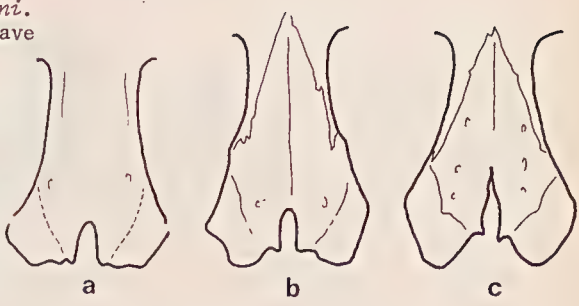

FIG. 14. - Outlines of the palatal regions of a, *Zaglossus robusta* (T.M. Z2031) b, *Zaglossus bruijni* (M9852) and c, *Tachyglossus aculeatus;* drawings are scaled to equal sizes to aid comparison.

Pectoral Limb and Girdle

The ventral (external) surface of the clavicles of the fossil is broader and flatter than *Z. bruijni*. The episternum is decidely more flared at the base than the long-beaked New Guinea form, but both the fossil and the living *Zaglossus* are more alike when compared with the narrow, triangular episternum of *Tachyglossus*. The pectoralis tubercle is well developed in the fossil and modern *Zaglossus* but is more ventrally disposed in the latter and *Tachyglossus*.

The epicoracoid facets on the medial, internal aspect of the clavicles are much deeper, broader impressions in the fossil form. They are almost equally represented on both clavicles, whereas *Z. bruijni* and *Tachyglossus* have markedly asymmetrical joint cavities. The clavicles of *Z. bruijni* also appear to be more acutely bowed, relatively slender and longer.

Differences in the scapula are also present. The glenoid fossa of the fossil and *Tachyglossus* is comparatively wider than that of *Z. bruijni*. The interior portion of the articular surface is gently rounded rather than tapered as in *Z. bruijni*. The living species have a less prominent supraglenoid tubercle for the proscapulohumeralis muscle. In the fossil form the triceps crest is relatively less prominent. The flange superior to the acromion (supracromical crest) for the acromiotrachelian muscle is comparatively weak in *Z. bruijni;* the omohyoid crest is only faintly visible. Due to the posterolateral flaring of the supracromial crest and concommitant torsion of the

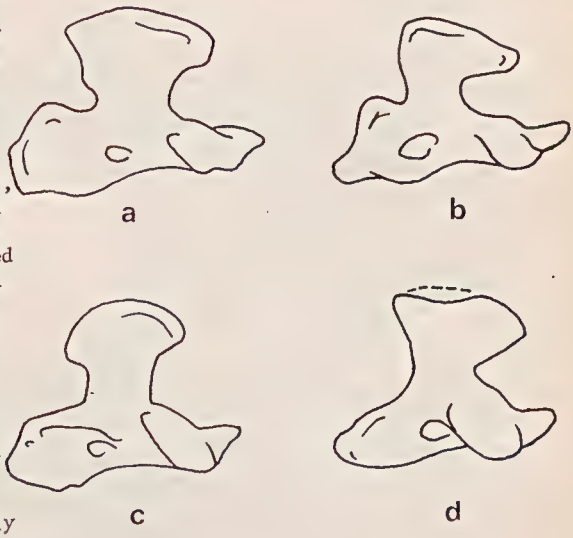

FIG. 15. - Outlines of the axis of a-b, *Zaglossus bruijni;* c, *Tachyglossus aculeatus*, d, *Zaglossus robusta;* Note in particular the broad, high crest in the transverse process in *Z. bruijni* for the attachment of longissimus cervicis. This feature is poorly developed in Z2031 and *Tachyglossus*.

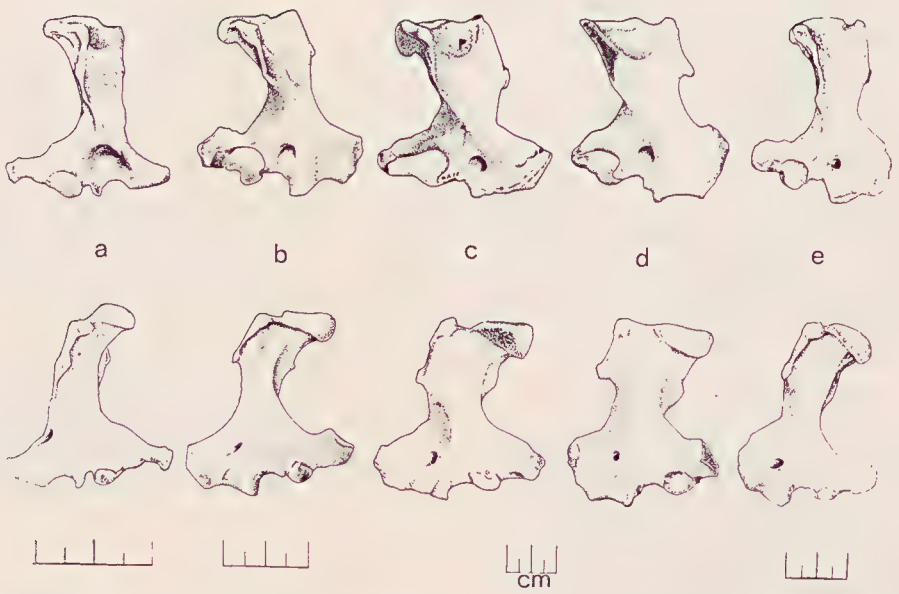

FIG. 16. - Monotreme humeri (right), scaled to equal sizes; a, *Ornithorhynchus anatinus;* b, *Tachyglossus aculeatus;* c, *"Ornithorhynchus maximus" = Zaglossus robusta;* c, *Zaglossus robusta* (T.M. Z2031); d, *Zaglossus bruijni.* Upper row; posterior aspect; lower row: inferior aspect (c, after Dun 1895).

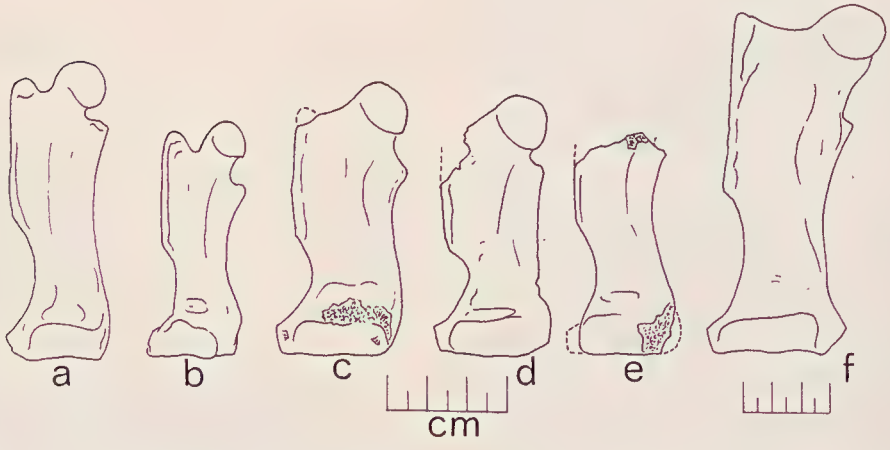

FIG. 17. - *Zaglossus* femora drawn to scale except for f which is reduced to 3/4x relative to a-e; a-b, *Zaglossus bruijni,* c, *Zaglossus robusta* (T.M. Z2031); d, *Zaglossus harrissoni* (QVM 13 or 1965: 39 : 5) *Zaglossus* sp. from Scotchtown Cave, Tasmania (reversed); f, *Zaglossus hacketti* (W.A. Mus. 60 : 10 : 1). (f, after Glauert, 1914).

acromioclavicular joint surface, the infraspinatus fossa appears deeper in the fossil form.

The humeri of all three species are morphologically similar (figure 16). Compared to *Z. bruijni* the posterior surface of the diaphysis of the fossil form is relatively broader and the entire shaft is proportionally shorter. The lesser tuberosity is more sharply demarcated from the head and is slightly more medially disposed in the fossil humeri. In *Z. bruijni*, the proscapulohumeralis muscle attachment is defined by a deep excavation of the superior portion of the posterior surface of the shaft. A crest extending from the lesser tuberosity to the head accentuates this fossa. The same area in the fossil humeri is convex rather than concave and the crest is weakly developed. The head of the humerus is broader in the fossil form.

In *Z. bruijni* the anterior border (brachialis crest) is a sinuous line. In the fossil species and *Tachyglossus* the anterior border is a smooth arc. The entepicondyle of *Z. bruijni* is shorter and more rounded than the fossil form. The deltoid tuberosity of *Z. bruijni* is situated relatively lower than either the fossil or *Tachyglossus*.

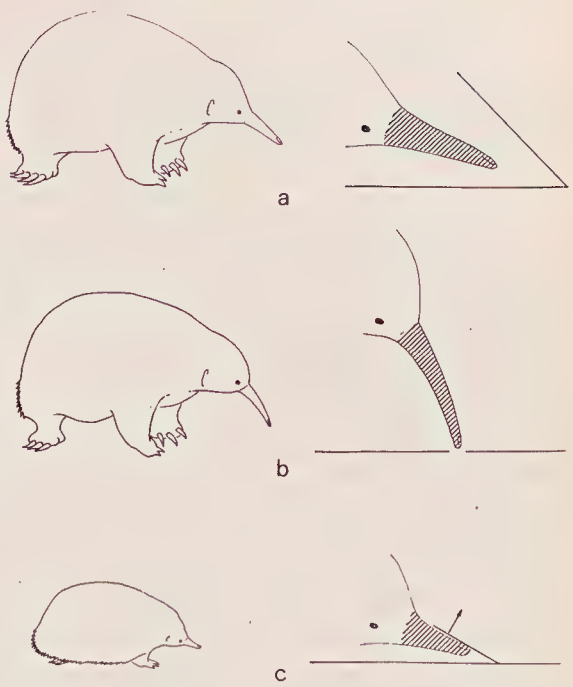

FIG. 18. - Inferred feeding adaptations in living and fossil tachyglossids. a, low angle feeding *(Zaglossus* Z2031, *Zaglossus robusta)*; b, vertical probing *(Zaglossus bruijni)*; c, low angle feeding and prying *(Tachyglossus aculeatus)*.

Dun (1895) described the right humerus of a fossil monotreme (Aust. Mus. F51453) as the remains of a giant platypus (*Ornithorhynchus maximus*). The morphology of this humerus is clearly different from living *Ornithorhynchus anatinus*, closely resembling the Pleistocene *Zaglossus* humeri from Montagu (figure 16 c, d).

There are fewer differences between the Gulgong and Montagu humeri than either shows with *Zaglossus bruijni*. The entepicondyle of the Gulgong specimen is slightly narrower and the dorsal opening of the entepicondylar foramen is larger in diameter. The differences between the Montagu and Gulgong specimens are within the normal range of morphological variation for *Zaglossus bruijni* or *Tachyglossus aculeatus*. The dimensions of the Gulgong humerus are almost identical with the Montagu specimens.

The Gulgong humerus can be readily distinguished from that of *Ornithorhynchus anatinus*. The entepicondyles of platypus humeri are much narrower, the entepicondylar foramen opens dorsally on the extreme margin of the entepicondyle, rather than near the centre of the base of the process as in tachyglossids generally; the shaft of the platypus humerus is narrower than the Gulgong form, or any tachyglossid, and is oriented more perpendicular to the long axis of the epicondyles. The platypus humerus has a proportionally much larger fossa surrounding the entepicondylar foramen, a considerably narrower intercondylar notch, a much broader deltoid crest, 5 to 10 degrees

more torsion of the head around the plane of the epicondyles and presents a deep fossa for the brachialis muscle.

The fossil humerus is from the same deposit in Canadian Lead Mine as the skull and axis of *Proechidna robusta*. It is highly probable that the humerus belongs to the same individual, and is reassigned to the Tachyglossidae: *Zaglossus (Proechidna) robusta* Dun 1895 (Mahoney and Ride, 1975, p.28).

Pelvic Limb and Girdle

The pelvic inlet is higher and narrower in the fossil species. The pubic angle is more acute, forming a wide "V" rather than a rounded profile. The pubic symphysis is proportionally much longer; the ischial rami form a relatively narrower and shorter arch. It is rounded at the juncture with the pubic symphysis rather than distinctly "V" shaped as in *Z. bruijni*. The ischial tuberosities are comparatively broader, shorter and less divergent distally in the fossil and the crest for the attachment of the rectus femoris muscle is relatively longer and tapers gradually into the ilia. In *Z. bruijni* the tubercle is abruptly relieved from the surface of the ilium. The facets for the attachments of the epipubic bones are more prolonged in the fossil, more closely approximated medially and terminate a greater distance superiorly from the pectineal tubercle.

The Mammoth Cave innominate specimen differs from the Montagu form in its much larger size and more oval acetabulae. It shares with the Montagu fossil a difference in the morphology of the tubercle for the rectus femoris muscle (Glauert, 1914).

The Montagu femora are considerably more compact than those of *Z. bruijni* and *Tachyglossus*. The intertrochanteric notches are less distinct in the fossil than in the living species. The anatomical neck is less distinct and is considerably broader than the head at its junction with the shaft in contrast to the living species. The lesser trochanter is conical and blunt rather than crested as in *Z. bruijni*.

The Montagu femora are conspecific with the specimen from King Island *(Z. harrissoni)*.

The range of variation in these femora (figure 17 c, d) is similar to that of the living *Zaglossus* species.

The femur from Scotchtown cave is only slightly more robust than that of a large female specimen of *Z. bruijni* figured in plate IX by Gervais (1878).

The femora of *Zaglossus hacketti* (Glauert, 1914) are much larger than the specimens from Tasmania. In addition, they display several distinctive features:

1) the shaft is relatively slender,
2) the epicondyles are relatively smaller,
3) the internal epicondyle is more prominent,
4) the lesser tuberosity is disposed inferiorly,
5) the greater trochanter extends further laterally.

The tibia of the living and extinct species of tachyglossids are distinguishable primarily on the basis of size. The tibial crest is relatively more prominent and rounded in the fossil form. The medial articular surface is level with the plane of the superior portion of the crest. In *Z. bruijni* the surface lies above the tibial crest. The tibial shaft in the fossil is slightly more concave on the medial side when compared with *Z. bruijni*. The origin of the tibialis anterior muscle is more deeply excavated in the fossil than in *Z. bruijni* or *Tachyglossus*.

The tibia of the Mammoth Cave specimen is a very stout, proportionally more massive bone than the other fossil or living tachyglossids. The concavity for the tibialis anterior muscle appears to be poorly expressed as it is in some living *Zaglossus* specimens. The shaft of the Mammoth Cave form is symmetrically biconcave rather than being strongly concave on the medial side only. Other differences include the very massive, short, less medially disposed styloid process.

The major morphological differences in the fibulae between the fossil and living species pertain to the shape of the flabelliform process. In the Montagu fossil this process is stouter, more rounded and all but devoid of thin, boney flanges. It is hook-shaped rather than squarish at its termination. The conical hook-like process for the lateral ligament is weakly developed in *Tachyglossus* and *Zaglossus bruijni*.

DISCUSSION

The Montagu and Gulgong fossils share a variety of morphological features with *Zaglossus bruijni* and *Tachyglossus aculeatus*. Certain other characteristics are unique to the large Pleistocene echidna.

Characteristics shared with *Tachyglossus* include:

1) rounded palatal arch; broad, blunt, relatively short, dorsoventrally compressed rostrum,
2) deep nasofrontal depression,
3) large temporal canal; posteriorly directed opening of foramen stylomastoideum primitivum,
4) narrow, tapered transverse processes on the axis and cervical vertebrae,
5) long, narrow occipital condyles,
6) compactly built humeri,
7) wide glenoid fossa of the scapula,
8) U-shaped outline of joined ischial rami.

Features shared with *Zaglossus bruijni*:

1) large overall size,
2) down-curved rostrum,
3) presence of a deep groove for the ascending facial vein,
4) bell-shaped episternum with prominent pectoralis tubercle,
5) shape and proportions of the neurocranium,
6) deep vacuity for the detrahens mandibulae muscle,
7) relatively small, shallow tympanic cavity.

Unique morphological features include:

1) overall robustness,
2) angled rather than arcing decurvation of the rostrum and palate; rostrum is distinctly less downcurved than *Zaglossus bruijni*, in proportion to its length,
3) tympanic cavity directed obliquely caudad, extremely shallow; swollen petrosal, lacks fissura petropterygoidea, recessus epitympanicus extends laterally beyond the margin of the tympanic cavity,
4) large, numerous nasofrontal foramina,
5) small epipterygoids,
6) extension of the palatine bones posteriorly to cover the medial border of the epipterygoids.

FUNCTIONAL MORPHOLOGY

The fossil form obviously exhibits a mosaic of morphological features that emphasize the great similarity of the two living genera. An attempt to explain the adaptive significance of some of these features may help clarify the position of the fossil form relative to *Zaglossus bruijni* and *Tachyglossus*.

Evidence suggests that the fossil species (excluding *Z. hacketti*) occupied a niche intermediate between those of the living genera. The shapes of the beaks of the living forms express their capacities to exploit special food resources (figure 18). The broad, slightly decurved rostrum of the fossil form was moderately efficient for vertical probing and upward prying, but optimum for low angle feeding. The strongly decurved, narrow and pointed rostrum of *Zaglossus bruijni* is best suited for vertical probing in a relatively soft substrate.

The short, slightly upturned broad, blunt rostrum of *Tachyglossus* is a modification for prying up rocks and woody debris, shallow probing and low angle feeding.

Both living genera are very adaptable and employ a variety of horizontal and vertical feeding postures (Van Deusen and George, 1969; Brattstrom, 1973). *Zaglossus bruijni* is the most limited because the long, curved beak is less efficient for vertical reaching and low angle probing and prying.

The fossil species displays certain features in common with *Tachyglossus* that pertain to the powerful digging action of the forelimbs and to the mobility and strength of the atlanto-occipital joint. The broader, more shallowly arching occipital condylar joint surfaces of *Z. bruijni* may reflect greater mobility of the head at the expense of loss of efficient support for lifting and prying with the beak. The long decurved rostrum of *Z. bruijni* necessitates increased vertical mobility of the head to reach the same levels as a form with an equally long but less down curved rostrum.

The powerful forelimbs of the fossil form are clearly not adaptations to support greater weight along since the animal is only marginally larger on a linear basis than the much more gracile living species. Its proportions are closer to *Tachyglossus* suggesting an ability to dig and tear into resistant materials. This ability is reduced in *Zaglossus bruijni*.

The fossil forms were probably entomophagus echidnas that exploited ants, termites and perhaps large beetle and moth larvae living in rotted wood. The relationship of the fossil *Zaglossus* to the New Guinea long beaked anteater is probably too remote to suggest a clinal variant analogous to the New Guinea *Tachyglossus aculeatus lawesi* and *T. aculeatus setosus*, though similar trends are apparent. *T. a. lawesi* contrasts with *T. a. setosus* in having a more slender rostrum and, also like *Z. bruijni*, there is a trend towards the reduction of the 3rd and 4th claws of the pes (Thomas, 1885, p.338). These features may have evolved in *Tachyglossus* since the isolation of New Guinea and Tasmania from the Australian Mainland in early post-glacial times.

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Dr. James Hopson, University of Chicago Department of Anatomy, offered valuable advice on anatomical terminology and brought to my attention important reference material. Dr. Ken Campbell, Department of Geology, Australian National University, made helpful comments on the manuscript. I wish to thank them both. I also extend my gratitude to Margaret Galbraith and Glenys Isaac for typing the manuscript.

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APPENDIX

MEASUREMENTS OF FOSSIL *ZAGLOSSUS* MATERIAL FROM MONTAGU, TASMANIA

Skull

mm.	no.	description
165.0	1	Condylobasal length
155.0	2	Occipitobasal length
139.0	3	Length, epipterygoids-premaxilla
95.5	4	Infraorbital canal to premaxilla
11.8	5	Width rostrum behind external nares
21.6	6	Width rostrum anterior to the root of zygomatic arch
23.2	7	Width of palate at orbital fissure
26.7	8	Width palate at foramen pseudovale
59.7	9	Width neurocranium at the anterior edge of temporal foraminen
11.3	10	Width across epipterygoids
13.9/ 5.6	11	Diameter anterior palatine fenestra
7.7/ 3.5	12	Dimensions median palatal cleft
11.8/ 7.3	13	Dimensions tympanic cavity
10.3/ 8.1	14	Dimensions jugular foramen
2.0/ 2.0	15	Dimensions foramen stylomastoideum primitivum
3.5	16	Thickness maxillary process of the palate
4.7	17	Depth of palatal arch at the level of the anterior root of malar
13.7/ 5.6	18	Dimensions external nares
5.9	19	Height rostrum behind external nares
14.1	20	Height of rostrum at the anterior root of the zygomatic arch
20.2	21	Height of rostrum at the level of the infraorbital foramen
45.0	22	Maximum height of braincase
4.5/ 2.8	23	Dimensions temporal foramen
3.4/ 3.4	24	Dimensions of foramen pseudovale
5.6/ 3.5	25	Dimensions optic fissure
3.0/ 2.0	26	Dimensions infraorbital canal
17.7/ 2.1	27	Dimensions facial vein groove
23.0/12.5	28	Dimensions occipital condyles
22.1/18.3	29	Dimensions foramen magnum
70.2	30	Length neurocranium

Pectoral girdle and limb

a. Clavicles and epicoracoid

33.1	1	Length episternum (includes height of clavicles)
34.6	2	Maximum width episternum
9.1	3	Minimum width episternum
11.2/ 4.6	4	Dimensions procoracoid articular surface
9.0	5	Depth cord of clavicular arch
10.0/ 7.6	6	Diameter clavicles
66.5	7	Combined length of clavicles

b. Scapula (Two individuals: 1 left and 1 right)

mm. left	mm. right	no.	description
22.6	19.2	8	Width subacromial notch
8.0	3.5	9	Depth subacromial notch
20.3	19.0	10	Width scapula above glenoid fossa
19.0/21.8	17.5/18.5	11	Dimensions glenoid fossa
	23.6	12	Length coracoid process

mm. left	mm. right	no.	description
	16.2	13	Minimum width coracoid process
	20.2	14	Maximum width coracoid process
	65.3	15	Length acromion to coracoid

c. Humerus (Two individuals: two right)

mm.	mm.	no.	
24.9/11.4	26.2/15.1	16	Dimensions head
	14.4	17	Lesser tuberosity to head
	28.1	18	Distance lesser tuberosity to teres major tubercle
	20.7	19	Width diaphysis posterior surface
	26.0	20	Height entepidondyle
	19.6	21	Height ectepicondyle
	66.5	22	Length capitulum to head
	77.0	23	Length from head to tubercle for flexor carpi radialis

mm.	no.	description
17.8/27.7	24	Dimensions "bicipital fossa"
3.4/ 3.4	25	Dimensions entepicondylar foramen, dorsal
8.9/ 8.7	26	Dimensions entepicondylar fossa
4.9/ 4.6	27	Dimensions entepicondylar foramen, ventral
17.8/ 4.5	28	Dimensions distal articular surface
62.3*	29	Distance across (width) distal end of humerus
13.4	30	Length inter condylar notch
44.5*	31	Distance across tuberosities

Innominate and pelvic limb

a. Innominate

22.8/20.9	1	Diameter acetabulum
12.7/ 9.1	2	Diameter acetabular fenestra
13.6/11.0	3	Diameter obturator foramen
61.3	4	Puboischium
40.5	5	Height of ischium posterior to acetabulum and obturator foramen
46.0	6	Length pubis
48.0/36.7	7	Diameter of pelvic inlet
20.8/16.0	8	Dimensions centrum sacral vertebra
41.8	9	Width across ischia
24.1	10	Depth ischipubic notch
38.1	11	Width across ischia
16.2/ 4.4	12	Dimensions epipubic bone articulation
24.0	13	Length pubic "symphysis"
46.5	14	Width across anterior inferior spine

b. Femur

16.0/16.8	15	Dimensions head of femur
77.0	16	Maximum length, head-lateral condyle
5.8*	17	Length intertrochanteric notch
38.7	18	Length greater trochanter
21.0	19	Distance lesser torchanter from head
24.5	20	Width diaphysis femur
35.8	21	Width distal articular surface femur
37.5	22	Width across trochanters
13.6/13.6	23	Dimensions medial condyle
13.5/11.1	24	Dimensions lateral condyle
8.6/ 9.5	25	Dimensions interocondylar notch

mm.	no.	description
c. Tibia and fibula		
96.0	26	Maximum length tibia (medial malleolus to head)
28.9/22.9	27	Dimensions proximal articular surface tibia
9.2	28	Width diaphysis tibia
7.7	29	Width flexor groove
17.6	30	Width distal end tibia
5.1	31	Length styloid process
107.0	32	Maximum length fibula
14.3	33	Length flabelliform process
8.5/13.5	34	Dimensions proximal articular surface
5.9	35	Width diaphysis fibula
6.7	36	Width distal articular surface
Axial skeleton		
a. axis		
27.5	1	Length neural spine
34.0	2	Maximum height vertebra
11.2	3	Minimum length
5.0/ 5.0	4	Dimensions transverse canal
42.7	5	Maximum length vertebra
16.2/12.5	6	Dimensions anterior articular surface
7.2	7	Length odontoid
8.3	8	Width neural arch
12.0/17.0	9	Dimensions neural canal
8.9	10	Height odontoid
28.6	11	Distance across anterior articular surfaces
13.0	12	Height transverse process

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SOME COMMON COMPONENTS OF THE PLANKTON OF THE SOUTHEASTERN COASTAL WATERS OF TASMANIA

by Nyan Taw
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(with 99 text-figures)

ABSTRACT

Zooplankton species found during studies of the zooplankton of the southeastern coastal waters of Tasmania are recorded, and discussed taxonomically where appropriate. A brief account is given of the distribution of the 71 pelagic copepods, eight euphausids, one sergestid, 11 chaetognaths and seven pelagic tunicates. Except for two copepod species which are assigned only to a genus, the remaining are positively identified to species level. Amongst the species recorded, 22 copepods are new to Australian waters whereas 38 copepods, one euphausid and two chaetognaths are new records for Tasmanian waters. Keys to the copepod genera and species are also given.

INTRODUCTION

The knowledge of Tasmanian marine plankton fauna, especially the copepods, is based almost exclusively upon materials collected by a few expeditions. The earliest contribution was from the Australian Antarctic Expedition (1911-1914) which operated a station off Maria Island and a station off the west coast of Tasmania. The Discovery Investigation Expeditions (1925-1927) operated a few stations around Tasmanian waters and another two stations were occupied by the British, Australian and New Zealand Antarctic Research Expedition (1929-1931) in southern Tasmanian waters.

Thomson (1947) and Thompson (1948) reported on the extensive studies of chaetognaths and pelagic tunicates respectively, found in the plankton hauls made by the C.S.I.R. Research Vessel "Warren" where the stations extended from the southern Queensland coast to South Australia and Tasmania.

Recently, the knowledge of Tasmanian euphausids was supplemented by a few stations operated around Tasmanian waters by Bradbury (1972) during his study on the seasonal distribution of Euphausiidae in the southern ocean adjacent to Australia.

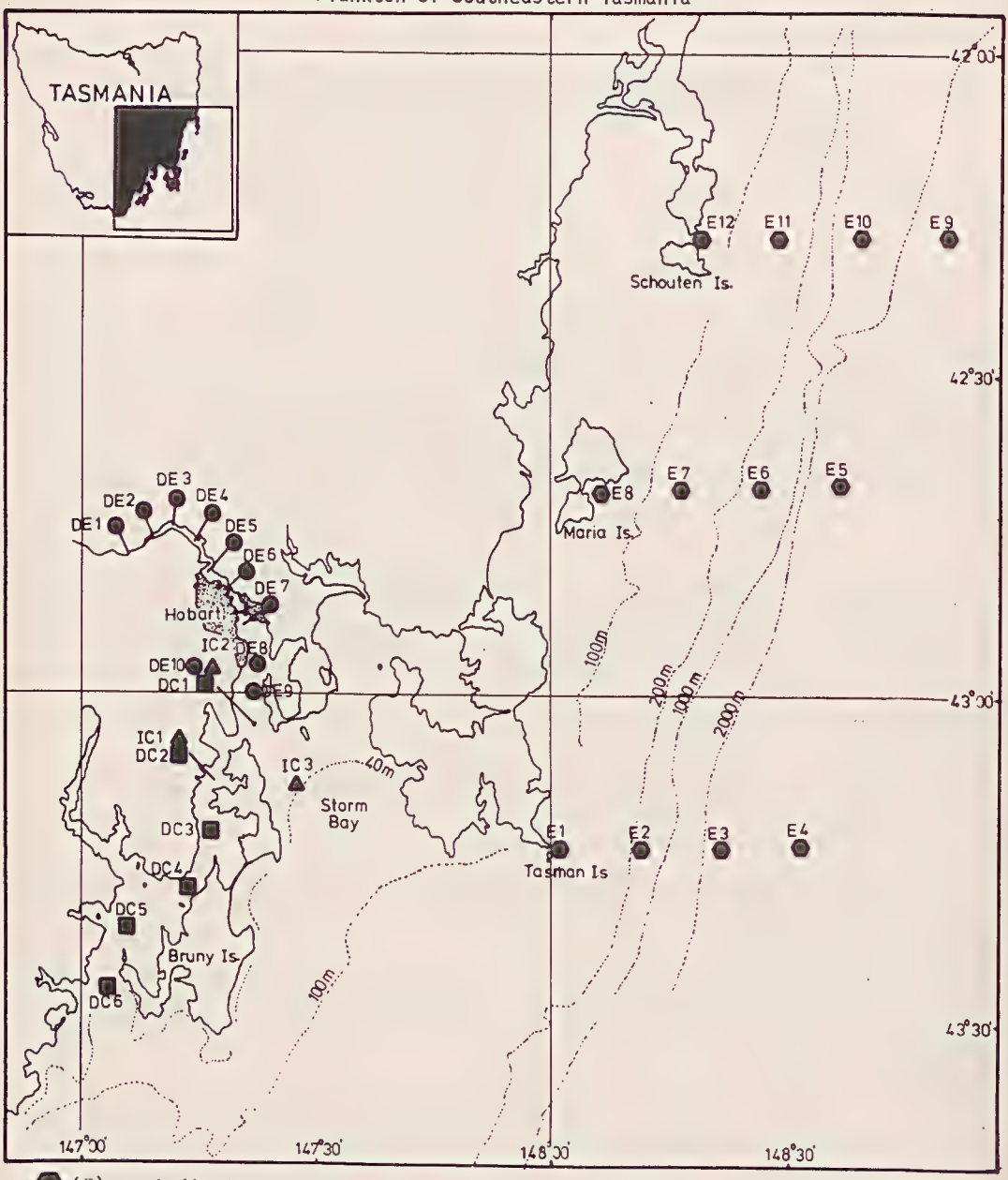
Dall (1957a & b, 1958) reported the distribution of zooplankton, mainly copepods, from the north and northeast of Tasmania. Kott (1957) reported the occurrence and composition of zooplankton on the material collected off New South Wales coast and Tasman Sea. Ong (1967) studied the zooplankton on the Derwent Estuary and recorded a few species.

The most extensive work on Australian marine plankton was done by Dakin and Colefax (1933, 1940) on the plankton samples collected off the coast of New South Wales.

Apart from these few studies, no detailed or lengthy study has been made on the Tasmanian marine and estuarine zooplankton. In particular, the copepod fauna, an important part of the marine plankton has not been investigated in detail.

The present paper provides a list, with figures, and key, of the major and common zooplankton groups found in the samples collected in the southeastern coastal waters of Tasmania. A more detailed account of their distribution has been presented by Nyan Taw (1975b).

Plankton of Southeastern Tasmania



(E) - indicates east-coast day stations: samples taken over a period of 2 years (June 1971 to May 1973) during which a total of 10 cruises were made approximately 1 to 3 months apart.

(IC) - indicates inshore coastal day and night stations: sampled once a month for a period of a year (August 1971 to July 1972).

(DC) - indicates D'Entrecastreaux Channel day stations: sampled once every 2 months for a period of a year (August 1972 to July 1973).

(DE) - indicates Derwent Estuary day stations: sampled during 2 cruises (October 1973 and April 1974).

FIG. 1. - Zooplankton stations in the southeast coastal waters of Tasmania.

Source of Material and Methods

The systematic account of the zooplankton presented in this paper was from the zooplankton samples collected in the southeastern coastal waters of Tasmania (fig. 1). The plankton samples were collected for four different studies, namely:

i. Water masses study off the east coast of Tasmania - stations indicated by the prefix 'E' (day stations; samples taken over a period of 2 years - June 1971 to May 1973 - during which a total of 10 cruises were made approximately 1 to 3 months apart),
ii. A comparative study on the seasonal diurnal vertical distribution of zooplankton in the inshore coastal waters of southeastern Tasmania - stations indicated by the prefix 'IC' (day and night stations; samples once a month for a period of a year - August 1971 to July 1972),
iii. A study on the zooplankton of D'Entrecasteaux Channel - stations indicated by the prefix 'DC' (day stations; sampled once every 2 months for a period of a year - August 1972 to July 1973), and,
iv. A study on the zooplankton of the Derwent Estuary - stations indicated by the prefix 'DE' (day stations; sampled during 2 cruises - October 1973 and April 1974).

Except for the comparative study of zooplankton in the inshore coastal waters, oblique tows were made in collecting the plankton samples: bottom to surface in D'Entrecasteaux Channel and Derwent Estuary zooplankton studies and 50m to surface in shallow water stations and 100m to surface in deep water stations in the East Coast water masses study. The plankton samples were preserved in approximately 5% formalin after each collection.

The East Coast water mass study plankton collections were made from F.R.V. "Penghana". The Zoology Department Research vessel "Neotrigonia" was used to collect the plankton samples for the remaining studies.

For taxonomic work on planktonic crustacea, the formalin preserved animal was immersed in a liquid mixture of glycerine and water having the ratio of 1:2 respectively. The mixed media containing the animal was kept in an oven (60°C) for about an hour, during which time the water in the mixed liquid evaporated and the animal was cleared and left in the pure glycerine. Thus the whole animal may be observed and studied from several angles.

The animal was dissected in the glycerine medium with a pair of minutent needles. The dissected parts were mounted in polyvinyl alcohol mounting fluid for detailed microscopic examination. A camera lucida was used to draw the animals and the parts dissected. Both compound and phase contrast microscopes were used in examining the whole animal and the parts dissected.

For salps and chaetognaths a dark-field condenser (Heron 1969) was used in identifying the specimens.

To be able to present a brief account of the occurrence of the zooplankton species, the study area is divided into four regions. The east coast area is divided according to the nomenclature given by Miller (1950) as coastal and oceanic, the oceanic waters being the region beyond 200m depth, and as such the stations in that area will be referred to as 'Oceanic' in giving the occurrence of a species. The remaining stations in the east coast is referred to as 'Coastal'. The stations occupied during the D'Entrecasteaux Channel zooplankton study and the comparative study of zooplankton in the inshore coastal waters are referred to as 'Inshore Coastal', due to the fact that the area is well inside the coastal region. The Derwent Estuary zooplankton study stations are divided according to Guiler's (1955) zonation such as freshwater to tidal and marine, in the present study they will be referred to as 'Estuarine' and 'Inshore Coastal' respectively.

The following list shows the stations in their appropriate regions:

OCEANIC - E2, E3, E4, E5, E6, E9 & E10.
COASTAL - E1, E7, E8, E11, & E12.
INSHORE COASTAL - IC1, IC2, IC3, DC1, DC2, DC3, DC4, DC5, DC6, DE7, DE8, DE9, & DE10.
ESTUARINE - DE1, DE2, DE3, DE4, DE5, & DE6.

If a species occurred five times or less, the stations where it was found are given, but if it occurred more than five times it will be assigned to the appropriate region or water mass.

Systematics

A total of 98 zooplankton species were recorded. The species consisted of 71 copepods, eight euphausids, one sergestid, 11 chaetognaths and seven pelagic tunicates. Except for two copepod species which were assigned only to a genus, the remaining were positively identified to specific level. Of all the species recorded, 22 copepod species are new to the Australian waters whereas 38 copepods, one euphausid and two chaetognaths are new records for Tasmanian waters.

The keys to copepod genera and species given are designed for the identification of the genera and species found in the present study area of the southeastern coastal waters of Tasmania. The key to the copepod genera was based on the keys given by Wilson (1932), Rose (1933), Dakin and Colefax (1940) and Bradford (1972).

The previous distributional records of the species given are derived from studies in the southern ocean, Australian region and major studies on the other oceans.

COPEPODA

Key to the Genera of Order Calanoida

1. Endopodites of legs 3 and 4, 3 segmented 2
   Endopodites of legs 3 and 4, 2 segmented 35
2. Endopodites of 1st leg, 3 segmented 3
   Endopodites of 1st leg, 2 segmented 13
   Endopodites of 1st leg, 1 segmented 17
3. Circular brown knob on right or left side of 1st. segment of metasome; 5th leg uniramous, 2-4 segments in female, 5 segments in male and asymmetrical.
   Pleuromamma. ♂ & ♀
   No such circular brown knob 4
4. Basal segment of endopodite of 2nd. leg deeply invaginated; with spines on the side of the invagination; female 5th. leg uniramous; 3-4 segments; male 5th. legs, 5 segments.
   Metridia. ♂ & ♀
   No such invagination or spines present 5
5. 3rd expodite of 3rd. and 4th. legs with one lateral spine, one at distal corner, and one terminal 6
   3rd. expodite of 3rd. and 4th legs with two lateral spines, one distal, and one terminal 10
6. Terminal spines of 3rd. expodites of 3rd and 4th legs with both margins smooth 7
   Terminal spines of this segment with one or both margins pectinate, denticulate, or setaceous 9
7. Forehead conical, slightly crested, male 5th. legs prehensile.
   Calanoides. ♂ & ♀
   Forehead not conical or crested 8
8. Inner margin of 1st. basipodite of 5th. legs smooth; 2nd. legs, with a recurved spine at the outer distal border of the 1st expodite segment; left 5th. leg in

male modified; 1st. antennae exceeds the body length by a few segments or exceeds the body length by half. *Neocalanus.* ♂ & ♀

Inner margin of 1st basipodite of 5th legs smooth; 2nd legs, without a recurved spine at the outer distal border of the 1st. exopodite segment; left 5th. leg in male modified; 1st antennae exceeds the body length by half. *Mesocalanus.* ♂ & ♀

Inner margin of 1st basipodite of 5th legs serrated (toothed); 2nd. legs without a recurved spine at the outer distal border of the 1st. exopodite segment; left 5th leg little modified in males; 1st antennae exceeds the body length by a few segments. *Calanus.* ♂ & ♀

9. 5th legs uniramous in female, 3 or 4 segmented; biramous in male, the endopod rudimentary or lacking, exopod 2 or 3 segmented, right uncinate. *Pseudodiaptomus.* ♂ & ♀

5th. legs biramous in both sexes; asymmetrical with well developed endopodite in male; symmetrical, a curved serrated or smooth spine-like process on the inner middle segment of endopodite; 1st. basipodite of 4th. leg with a sword-like spine in female (except in *G. symmetricus*). *Gladioferens* ♂ & ♀

5th legs biramous in both sexes; asymmetrical in male exopodite 3 segmented forming a long narrow curved claw; symmetrical in female with toothed process on the inner middle segment of endopodite, two lobes on the last metasomal segment projected posteriorly in females. *Boeckella.* ♂ & ♀

10. Left and sometimes right furcal ramus with one seta thicker than the others and greatly elongated; rami of 2nd. antennae approximately equal length; middle segment of the exopodite of 5th. legs in female with smooth inner spine; 2nd basipodite of right 5th. leg in male with sausage-shaped process; all setae of 2nd maxilla transformed into stout spines. *Heterorhabdus.* ♂ & ♀

Setae of furcal rami neither thicker nor elongated 11

11. Females only; 1st antennae symmetrical; 5th. legs biramous, symmetrical with plumed setae, and with rami 3 segmented; middle segment of exopodite of 5th. legs with large inner spine; end segment with denticulate terminal spine, exopodite of 2nd. antennae 6 segmented. *Centropages.* ♀

Males only; 1st. antennae asymmetrical 12

12. Right 1st. antenna modified, geniculate; left exopodite of 5th. leg 2 segmented, right 3 segmented; endopodites symmetrical and 3 segmented; exopodite of 2nd antenna 6 segmented, its basal segment often very short. *Centropages.* ♂

Left 1st. antenna geniculate; 5th. legs asymmetrical, rami of left 3 segmented, the right 2 segmented; distal segment of right exopodite shuts down against proximal one to form a chela. *Lucicutia.* ♂

13. Both rami of 5th. legs symmetrical, 3 segmented and armed with plumose setae; exopod of 1st. antennae 8 segmented; 5th. and 6th. metasomal segments fused. *Lucicutia.* ♀

5th. legs asymmetrical in both sexes; uniramous and 3 segmented in female; left leg uniramous, right biramous both strongly modified in male; 2nd. maxilla bears unusually long, strong denticulate spine which reaches forward as far as the eyes. *Sulcanus.* ♂ & ♀

Endopodite of 5th. legs rudimentary or lacking; sometimes the whole leg is wanting on one or both sides. 14

14. Furcal rami only three times as long as wide or less; middle segments of endopodite of 3rd and 4th legs with 2 setae and end segment with 7 setae 15

Furcal rami as above; middle segment of endopodite of 3rd. and 4th. legs with one seta, end segment with 5 setae 16

15. End seta of exopodite of 2nd., 3rd. and 4th. legs with its outer margin smooth in both sexes; outer margin of 2nd., 3rd. and 4th. leg of exopodite not toothed; 5th legs uniramous; 3 or 4 segmented in females; in male, right 5th. leg 4 segmented, left 5 segmented. *Calocalanus.* ♂ & ♀

Outer margin of the exopodite of 2nd, 3rd. and 4th. legs toothed; 5th. legs present in both male and female, 2 segmented and uniramous in female, in male, right leg 2 segmented, left leg 5 segmented; exopodite of 2nd. antenna shorter than endopodite and 7 segmented. *Paracalanus.* ♂ & ♀

16. Exopodite of 1st. legs 2 segmented; female 5th. legs uniramous, 3 segmented; left male 5th. leg biramous, right uniramous with only one segment. *Rhincalanus.* ♂ & ♀

Exopodite of 1st. legs 3 segmented; 5th. legs absent in females; endopodite of 2nd. antenna longer than exopodite; end spines of the exopodite of 2nd. to 4th. legs with smooth margins; male 5th. legs uniramous. *Eucalanus.* ♂ & ♀

17. Endopodite of 2nd. legs 3 segmented; exopodite of 2nd. antennae half as long as endopodite; abdomen 3 segmented in female, 4 segmented in male; 5th. legs alike in both sexes, symmetrical and 5 segmented. *Mecynocera.* ♂ & ♀

Endopodite of 2nd. leg 2 segmented 18

Endopodite of 2nd. leg 1 segmented 29

18. Posterior surface of the rami of 3rd and 4th. legs armed with spines 19

Posterior surface of the rami of 3rd and 4th legs smooth ... 23

19. Metasome wide, always globular in shape *Phaenna* ♀

Metasome elongated, elliptical in shape 20

20. 5th. legs present, males only 21

5th legs absent, females only 22

21. 5th. legs biramous on one side only; 2nd. maxilla with worm-like appendages without spiny hooked setae; squat and thick stylet. *Scolecithrix.* ♂

5th legs biramous on both sides; left endopodite of 5th. leg much longer than exopodite with one segment, right endopodite with one segment. *Racovitzanus.* ♂

22. 3rd. exopodite segment of 2nd, 3rd. and 4th legs with 4 internal setae; posterior corner of metasome rounded; genital segment projecting ventrally. *Scolecithrix.* ♂

3rd. exopodite segment of 2nd., 3rd. and 4th. legs with 4 internal setae; genital segment without ventral projection; rostrum with two small points; second maxilla with special terminal setae. *Racovitzanus.* ♂

23. Basal segments and exopodite of 2nd. and 3rd. legs much broader than in 4th. leg; distal margin of 2nd. basal segment with strong teeth; terminal setae of exopodite of 3rd. leg broad and blade-like; female 5th. legs uniramous, 3 segmented; male 5th legs uniramous, left 5 segmented, right 1 to 3 segmented. *Clausocalanus.* ♂ & ♀

Basal segments and exopodites of 2nd. and 3rd. legs do not show the above differences with the 4th. legs 24

24. 1st. and 2nd. marginal setae of 3rd. and 4th. legs comb-like. *Ctenocalanus.* ♂ & ♀

1st. and 2nd. marginal setae of 3rd. and 4th. legs normal. 25

25. 5th legs present asymmetrical. 26

5th legs absent 27

26. Endopodite of 1st. leg with 2 external spines; right 5th leg absent. *Aetideus.* ♂

Endopodite of 1st. leg with 3 external spines; rostrum absent. *Chiridius.* ♂

27. Head without spine; exopodite of 3rd. segment of 3rd. and 4th. legs with 4 inner setae; inner margin of basipodite segment 1 of 4th. leg naked or setose; posterior corner of metasome rounded; genital segment more or less asymmetrical with a lateral or ventral spine. *Undeuchaeta.* ♀

Head without spine; exopodite of segment 3 of 3rd and 4th. leg with 4 inner setae; inner margin of basipodite segment 1 of 4th. leg naked or setose; posterior corner of metasome terminated by a sharp point. 28

28. Rostrum absent; exopodite of 2nd. antenna longer than endopod; exopodite of 1st.

leg with 3 external spines; 2nd. maxilla without worm-like appendages. *Chiridius.* ♀

Rostrum thick, the two points separated down at the base; exopodite of 1st leg with 2 external spines. *Aetideus.* ♀

29. Head without medium dorsal spine; 5th. leg absent. 30
Head without medium dorsal spine; 5th. leg present, asymmetrical ... 32

30. Posterior corner of metasome extended to a strong point; 1st. basipodite of 4th. leg without spines or spinules; rostrum absent. *Chiridius.* ♀
Posterior corner of metasome rounded or bluntly pointed. 31

31. 1st. basipodite of 4th. leg with one or many spines or spinules on the internal margin; endopodite of 2nd. antenna at the most half the length of exopodite; exopodite of 1st. leg 2 segmented. *Euchirella* ♀
1st. basipodite of 4th. leg without spines or spinules; both branches of 2nd. antenna nearly equal; maxilliped smaller, about as long as the head; two of the furcal setae always naked and usually much longer than others. *Euchaeta.* ♀

32. 5th. leg present on only one side, without endopodite or with very small exopodite. *Aetideus.* ♂
5th leg with endopodite well developed. 33

33. Exopodite of left 5th. leg terminated by one very long, very thin segment, often stylet-shaped; exopodite of right 5th leg end in short pincers; right endopodite always rudimentary, 1st. antenna with very long isolated setae. *Euchaeta.* ♂
These features absent. 34

34. Exopodite of left 5th. leg ends in a short pointed segment with a tuft of hairs on the inside; left endopodite less than half the length of right endopodite, basal segment very swollen. *Undeuchaeta.* ♂
Exopodite of left 5th. leg rarely pointed; either without hairs, or when hairs present never arranged in tufts; exopodite of 1st. leg with 2 segments; endopodite of 2nd. antenna at most half the length of exopodite. *Euchirella.* ♂

35. Head with a pair of dorsal lenses; endopodite of 1st. legs with 2 segments; 5th. legs biramous in female, rami 1 segmented; in male right 5th. leg uniramous with chela. *Labidocera.* ♂ & ♀
No dorsal lenses; 5th. legs uniramous in both sexes. 36

36. Maxilliped 3-4 segmented; exopodite of 2nd. antennae shorter than the distal segment of endopodite; 2nd. maxilla with long spiny bristles on proximal and distal parts. *Acartia.* ♂ & ♀
Maxilliped 7 segmented. 37

37. Furca at least six times as long as wide; maxilliped twice as long as 2nd. maxilla. *Temora.* ♂ & ♀
Furca at the most four times as long as wide; maxilliped shorter than 2nd. maxilla; 2nd. maxilla with short bristles on the proximal part and long scythe-like bristles on the distal part; proximal basal segment of maxilliped with few short bristles. *Candacia.* ♂ & ♀

Order CALANOIDA

Family CALANIDAE

Calanus australis Brodsky, 1959
(figs 2a - d)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort, 1957); Mouth of River Derwent, D'Entrecasteaux Channel (Ong 1967, 1970; Ong and Lake 1970) as *Calanus helgolandicus*.
Occurrence: Inshore Coastal, Coastal and Oceanic.

Notes

The species encountered in the present study agrees with Brodsky's (1959, 1961) description of *Calanus australis*. This species was recorded by Ong (1967, 1970), Ong and Lake (1970) as *C. helgolandicus*. However, examination of the photographs (plate 19, lateral view of adult female and plate 20, serrated margin of the first basipodite of female 5th. legs) of Ong (1967) reveals that the number of teeth on the first basipodite of female 5th. legs was less than 17 on either side and the teeth were pointed and triangular.

Figure Explanations:

(a) male whole animal, lateral view,
(b) female whole animal, lateral view,
(c) male fifth leg, posterior aspect,
(d) female fifth leg, posterior aspect.

Calanus minor (Claus, 1863)
(figs 3a - d)

Previous Tasmanian Records: Nil.
Occurrence: Inshore Coastal, Coastal and Oceanic.
Figure Explanations:

(a) male whole animal dorsal view,
(b) male fifth leg, posterior aspect,
(c) female last metasomal segment and urosome lateral view,
(d) female fifth leg, posterior aspect.

Calanoides carinatus (Kroyer, 1849)
(figs 4a - c)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort, 1957).
Occurrence: Inshore Coastal, Coastal and Oceanic.
Figure Explanations:

(a) female whole animal, dorsal view,
(b) female fifth leg, posterior aspect,
(c) female whole animal, lateral view.

Mesocalanus tenuicornis (Dana, 1848)
(figs 5a - d)

Previous Tasmanian Records: Nil.
Occurrence: Inshore Coastal, Coastal and Oceanic.
Figure Explanations:

(a) female whole animal, lateral view,
(b) male fifth leg, posterior aspect,
(c) female fifth leg, posterior aspect,
(d) female urosome, ventral view.

Neocalanus robustior (Giesbrecht, 1891)
(figs 6a - e)

Previous Tasmanian Records: Nil.
Occurrence: Coastal and Oceanic.
Figure Explanations:

(a) female whole animal, dorsal view,
(b) female first leg, anterior aspect,
(c) female last metasomal segment and urosome, lateral view,
(d) female second leg showing first endopodite and first exopodite, posterior aspect,
(e) female second maxilla, lateral view.

Neocalanus tonsus (Brady, 1883)
(figs 7a - d)

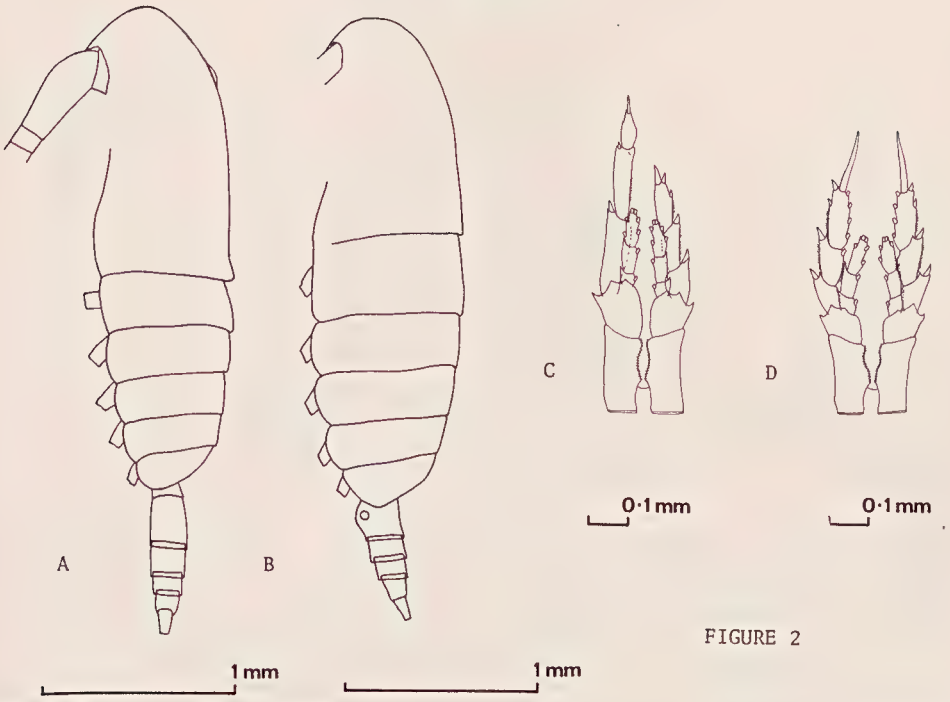


FIGURE 2

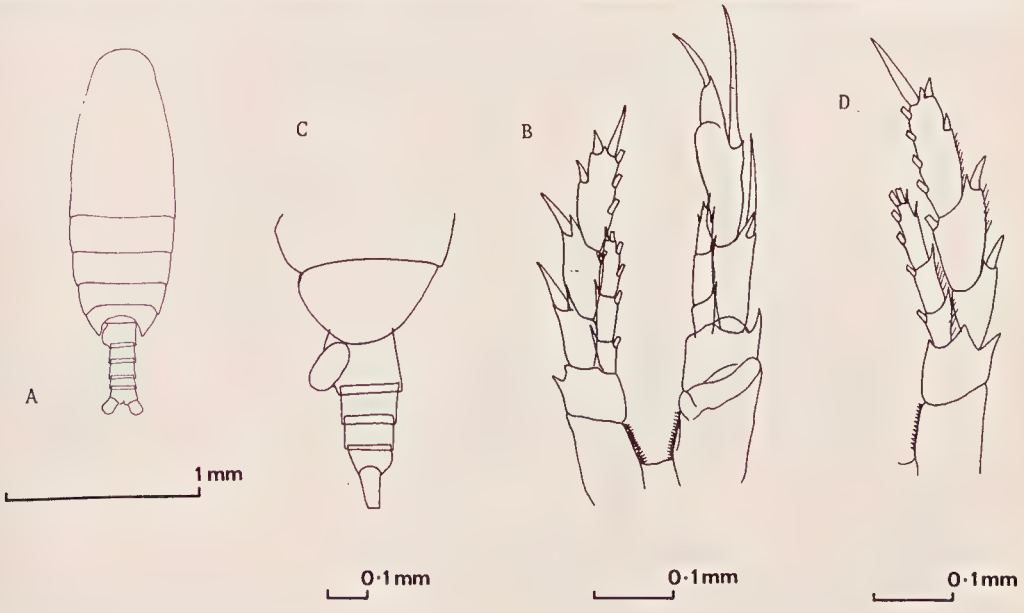


FIGURE 3

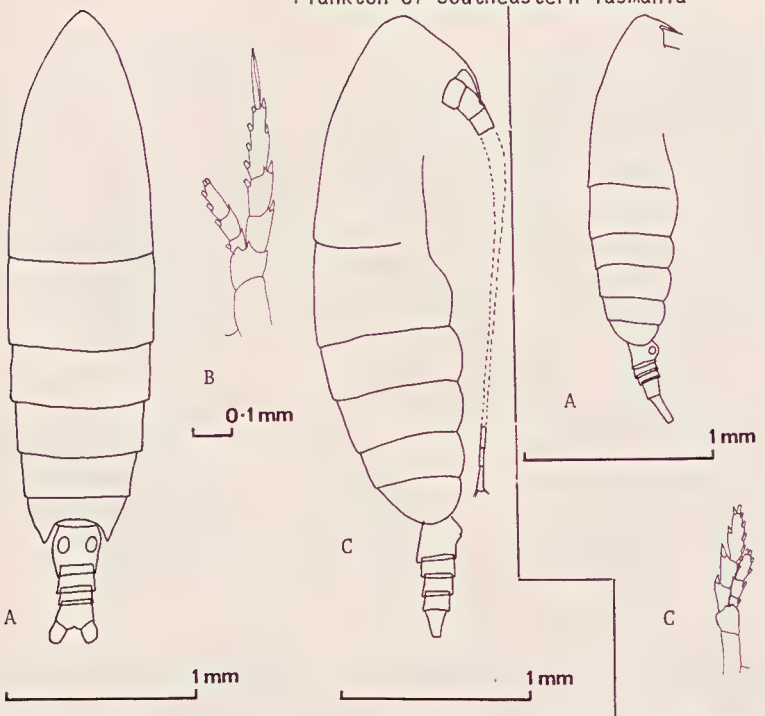


FIGURE 4

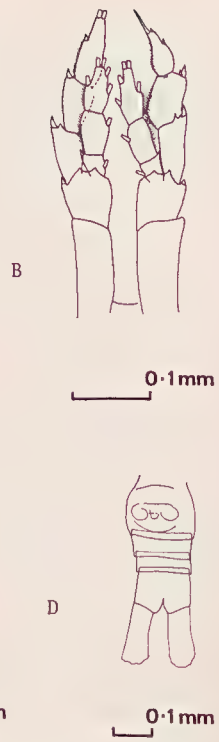


FIGURE 5

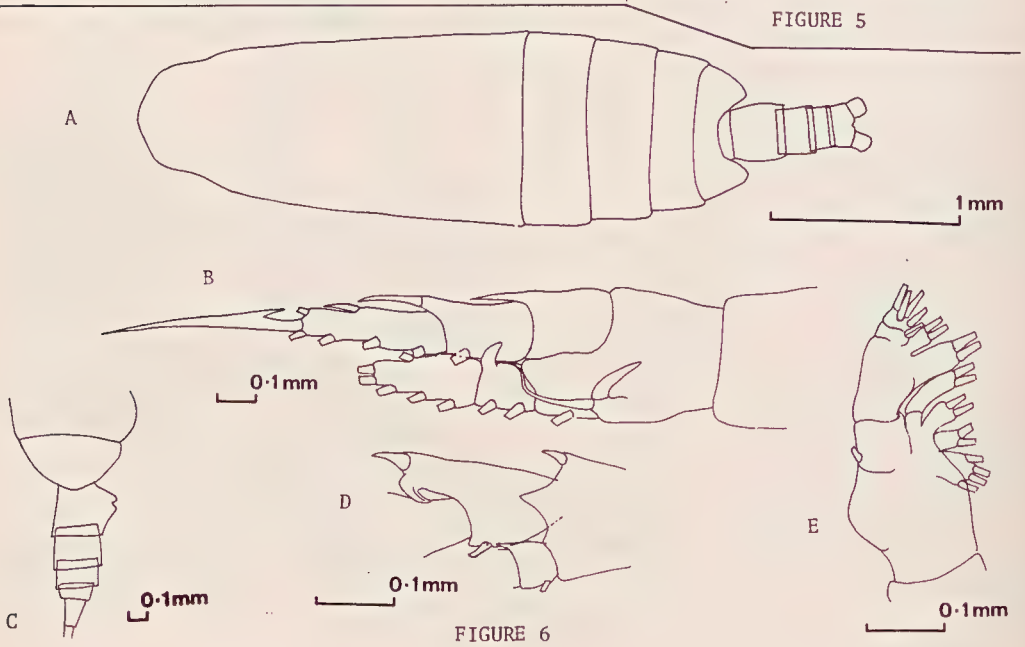


FIGURE 6

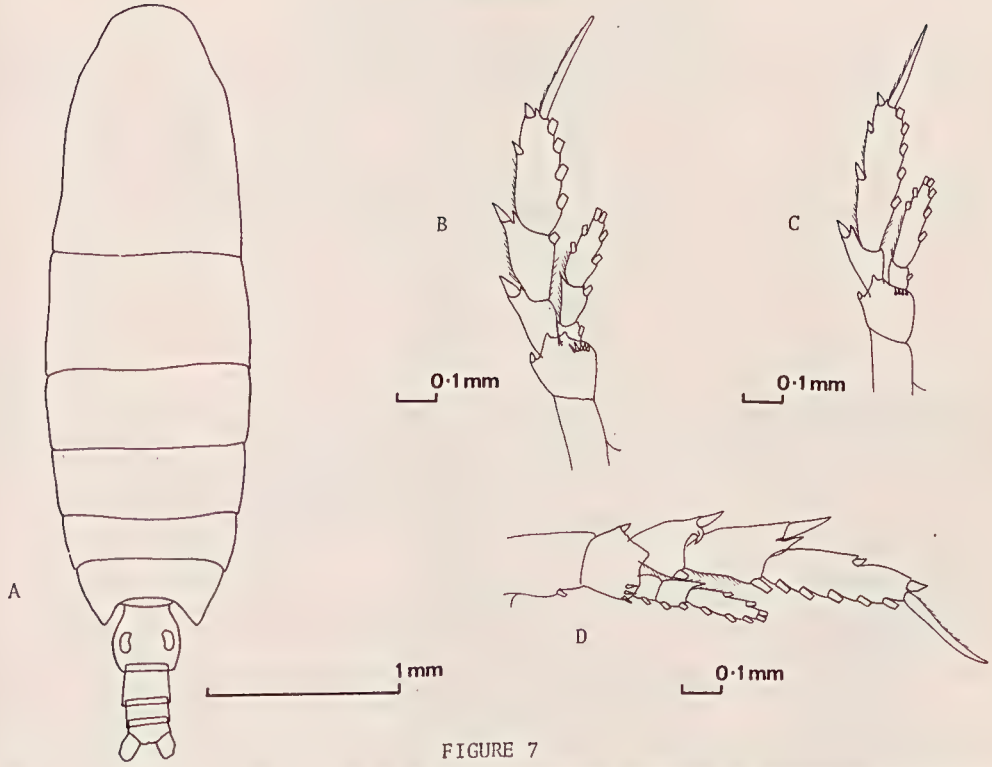


FIGURE 7

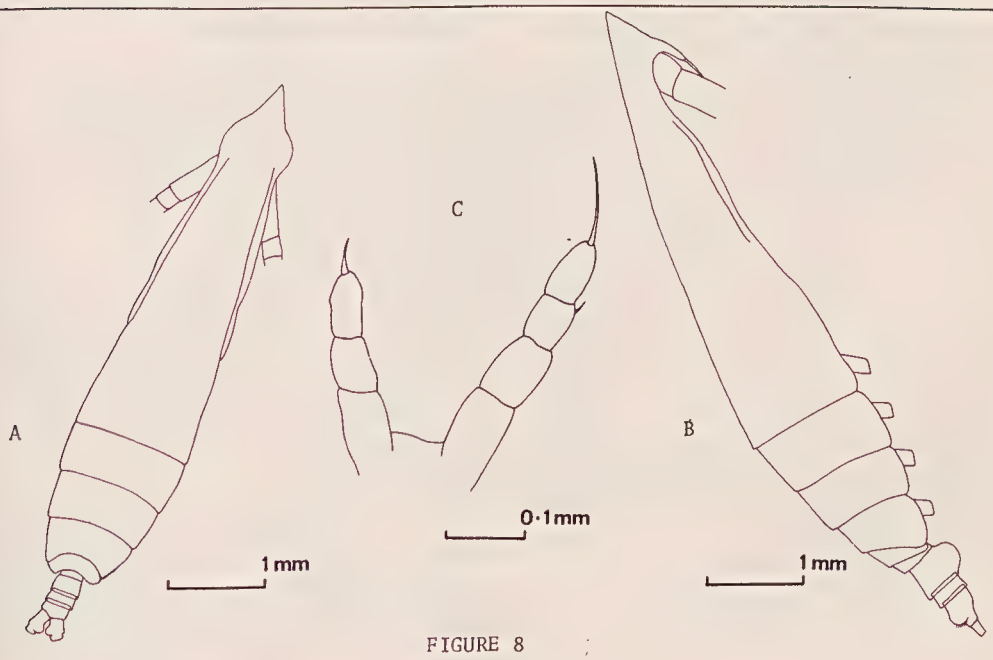


FIGURE 8

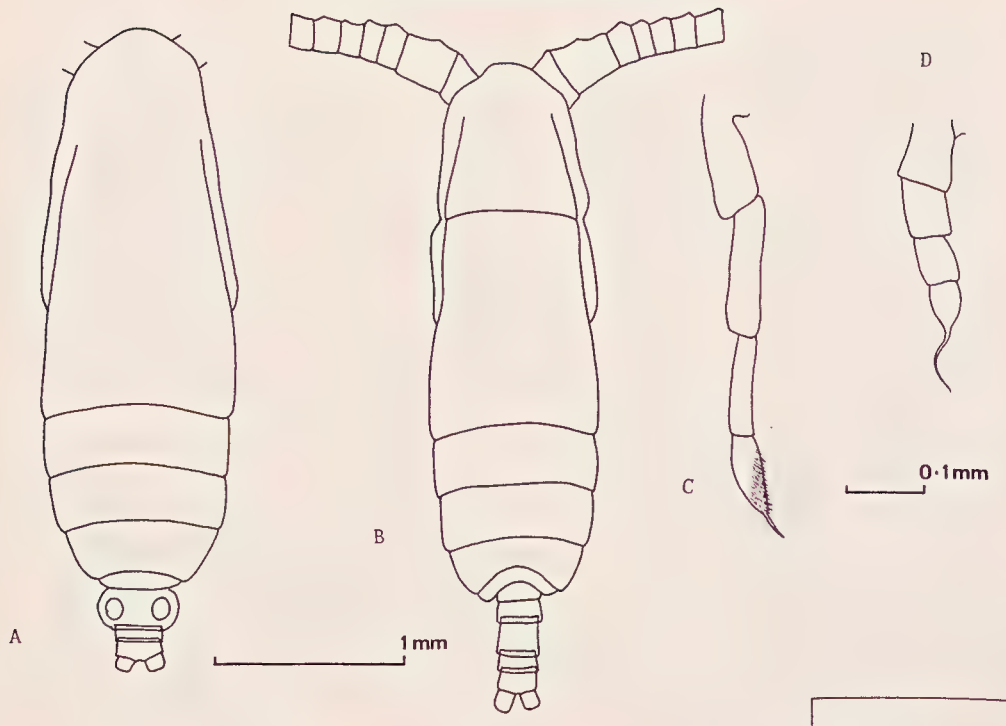


FIGURE 9

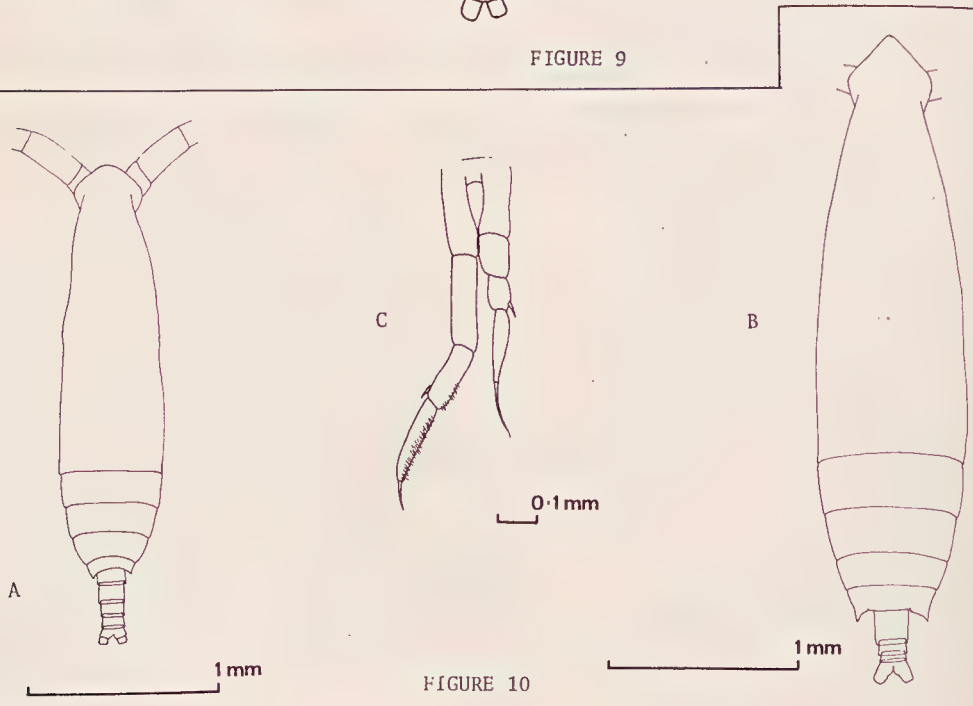


FIGURE 10

Reference Specimen: Tranter, C.S.I.R.O., Cronulla, Bottle No. 18, Sample No. South Coast N.S.W.
Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort, 1957).
Occurrence: Inshore Coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fifth leg, posterior aspect,
(c) female fifth leg of fifth copepodite stage, posterior aspect.
(d) female second leg, posterior aspect.

Family EUCALANIDAE
Genus *Eucalanus*

Key to the Species

Female - Urosome with 3 - 4 segments, the last of which is fused with the furca; genital aperture on the ventral surface, which is longer and broader than the following segment; fifth legs absent.
Male - Urosome with five segments; genital aperture on the left side of the first segment; fifth legs asymmetrical.

Key to the Females of the Species

1. Urosome 4 segmented. *E. elongatus*
   Urosome 3 segmented. 2
2. Forehead flatly rounded, genital segment onion shaped, much broader than long; tooth lacking on outer margin of second endopodite of second to fourth legs. *E. crassus*
   Forehead triangular, metasome elongated. 3
3. Forehead triangular and very elongate; furcal rami broader than long. *E. longiceps*
   Forehead triangular and elongate; furcal rami as long as broad or longer. *E. attenuatus*

Key to the Males of the Species

1. Both fifth legs present 2
   Only left fifth leg present 3
2. Forehead triangular, bluntly rounded anteriorly; posterior corner of the last metasomal segment pointed. *E. elongatus*
3. Forehead triangular, very elongated and pointed anteriorly metasome elongate. *E. longiceps*
   Forehead flatly rounded, metasome not elongate. *E. crassus*

Eucalanus attenuatus (Dana, 1848)
(figs 8a - c)

Previous Tasmanian Records: Nil.
Occurrence: Coastal and Oceanic.
Figure Explanations:
(a) immature male whole animal, dorsal view,
(b) female whole animal, lateral view,
(c) immature male fifth leg.

Eucalanus crassus (Giesbrecht, 1902)
(figs 9a - d)

Previous Tasmanian Records: Nil.
Occurrence: Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) male whole animal, dorsal view,
(c) male fifth leg,
(d) immature male fifth leg.

Eucalanus elongatus (Dana, 1848)
(figs 10a - c)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort, 1957).
Occurrence: Coastal and Oceanic.
Figure Explanations:
(a) male whole animal, dorsal view,
(b) female whole animal, dorsal view,
(c) male fifth leg.

Eucalanus longiceps Matthews, 1925
(figs 11a - d)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort, 1957).
Occurrence: Coastal and Oceanic.
Figure Explanations:
(a) male whole animal, lateral view,
(b) female whole animal, dorsal view,
(c) male head, lateral view,
(d) male fifth leg.

Mecynocera clausi Thompson, 1888
(figs 12a & b)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort, 1957).
Figure Explanations:
(a) female whole animal, lateral view,
(b) female fifth leg.

Rhincalanus nasutus (Geisbrecht, 1888)
(figs 13a - c)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort, 1957).
Occurrence: Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) male fifth leg,
(c) female fifth leg.

Family PARACALANIDAE
Genus *Calocalanus*

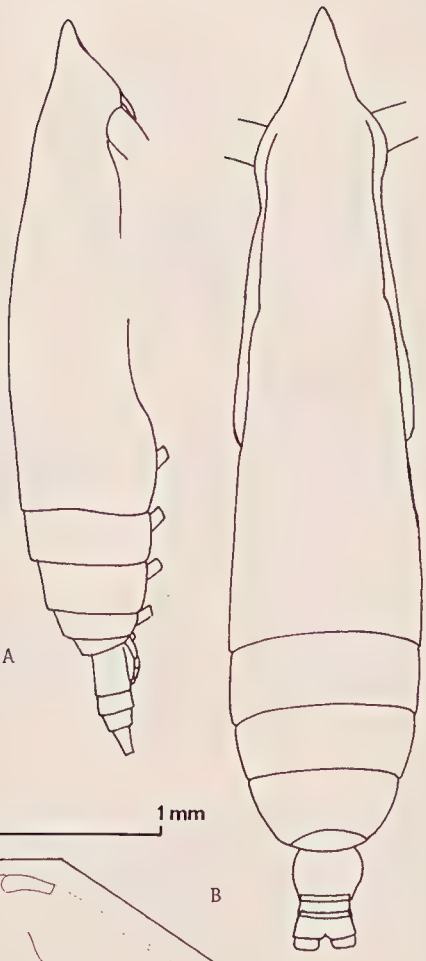
Key to the Females of the Species

1. Urosome 2 segmented; body stout; genital segment onion shaped, broader than long; female fifth leg 4 segmented with four or five apical setae; furcal rami two times as long as wide and widely divergent; length 0.88 - 1.2mm. *C. pavo*

   Urosome 3 segmented; body stout or slender; genital segment onion shaped or normal; furcal rami as long as wide. 2
2. Metasome slender and fusiform; genital segment longer than broad; fifth legs four segmented with three apical setae; furcal rami parallel. *C. tenuis*

   Metasome stout or little slender; genital segment onion shaped; fifth legs three segmented; furcal rami slightly divergent. 3
3. Metasome stout; genital segment partly covering the second segment; fifth legs with one terminal setae. *C. styliremis*

   Metasome little slender, fifth legs with two terminal setae. *C. contractus*



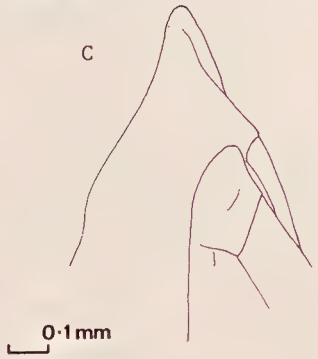


FIGURE 11

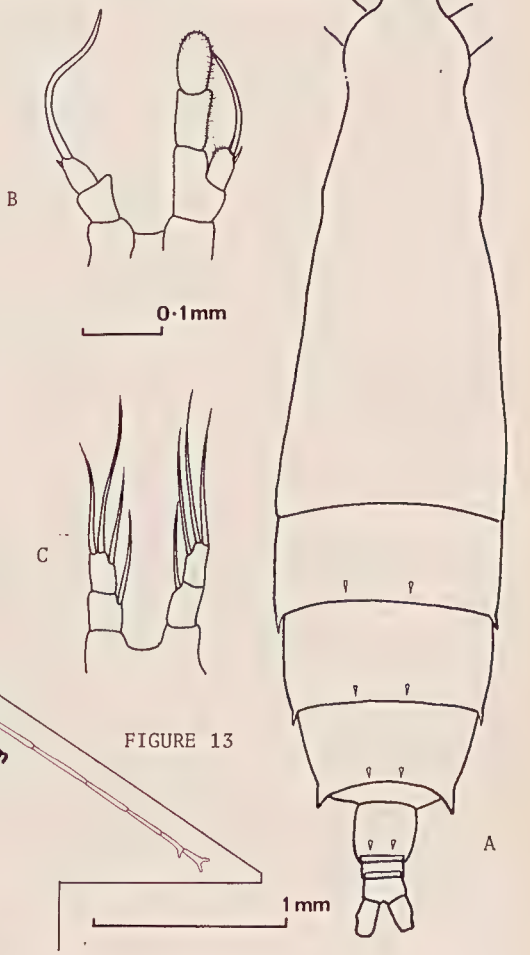


FIGURE 13

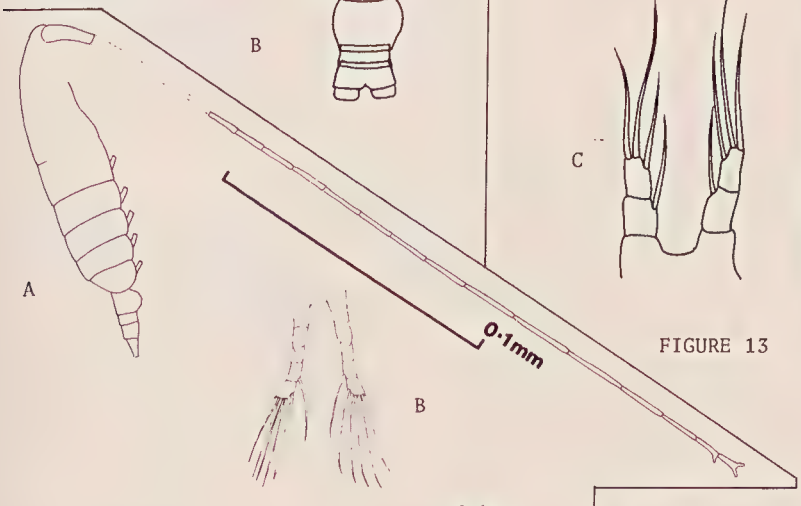


FIGURE 12

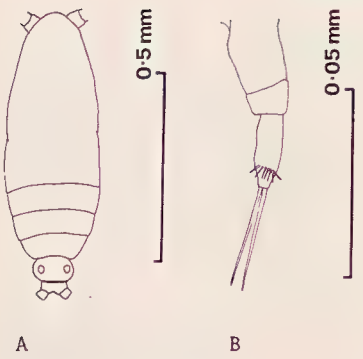


FIGURE 14

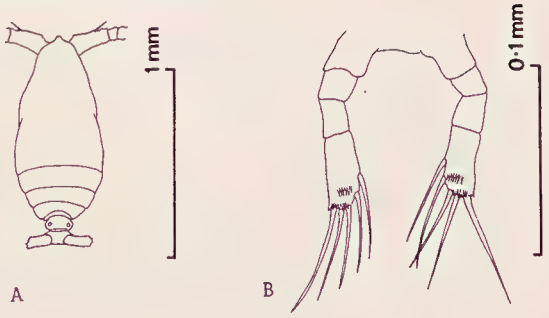


FIGURE 15

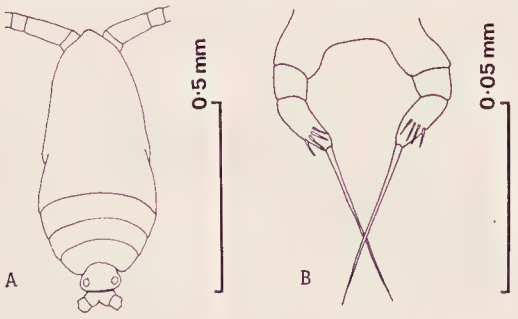


FIGURE 16

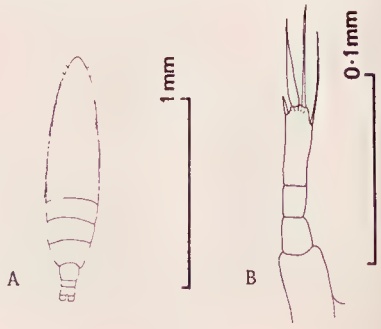


FIGURE 17

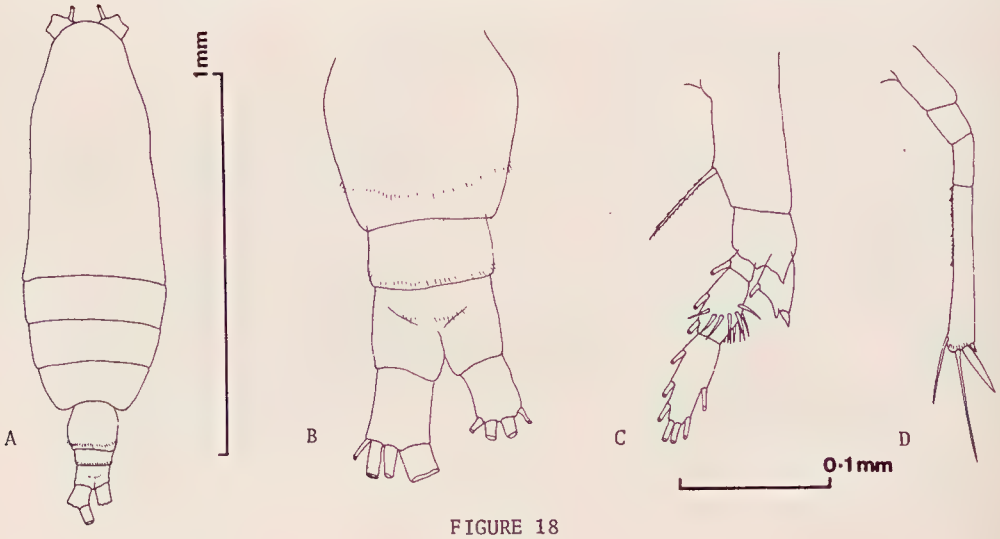


FIGURE 18

Calocalanus contractus (Farran, 1936)
(Figs 14a & b)

Previous Tasmanian Records: Nil.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fifth leg.

Calocalanus pavo (Dana, 1848)
(figs 15a & b)

Previous Tasmanian Records: Nil.
Occurrence: Inshore Coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fifth leg.

Calocalanus styliremis (Giesbrecht, 1888)
(figs 16 a & b)

Previous Tasmanian Records: Nil.
Occurrence: Inshore Coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fifth leg.

Calocalanus tenuis (Farran, 1926)
(figs 17a & b)

Previous Tasmanian Records: Nil.
Occurrence: Inshore Coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fifth leg.

Leptocalanus plumulosus (Claus, 1863)
(figs 18a - d)

Previous Tasmanian Records: Nil.
Occurrence: Inshore Coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female urosome, dorsal view,
(c) third leg (without distal expodite segment),
(d) female fifth leg.

Paracalanus parvus (Claus, 1863)
(figs 19a - g)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort, 1957).
Occurrence: Estuarine, Inshore Coastal, Coastal and Oceanic.
Figure Explanations:
(a) male whole animal, lateral view,
(b) male fourth leg, posterior aspect,
(c) male fifth leg,
(d) female second leg, posterior aspect,
(e) female whole animal, lateral view,
(f) female mandible,
(g) female fifth leg.

Family PSEUDOCALANIDAE
Genus *Clausocalanus*

Key to adult females of the Species

1. In lateral view ventral profile of genital segment conspicuously protruberant anterior to genital pores; rostrum short, slender and curved in lateral view. *C. jobei*
   In lateral view ventral profile of genital segment not conspicuously protruberant anterior to genital pore. 2
2. Third segment of fifth legs less than 2.0 times as long as first segment of the same leg 3
   Third segment of fifth legs more than 2.0 times as long; as first segment of the same leg. 5
3. Forehead usually strongly vaulted spiniform of the second basipodite of the third leg narrow and uniformly taped from the base. *C. laticeps*
   Forehead not vaulted; spiniform processes of the second basipodite of the third leg thick and not uniformly tapered from base 4
4. In lateral view rostrum slender and curved, in lateral view forehead broadly rounded, protruberant above rostrum; in lateral view the dorsal lobe of seminal receptacle large and originates from the anterior part of the ventral lobe and is directed dorsoanteriorly. *C. ingens*
   In lateral view rostrum thick and usually curved ventroposteriorly; in lateral view forehead broadly rounded but not markedly protruberant above rostrum; in lateral view dorsal often inconspicuous, long and slender, usually directed dorsally or dorso-anteriorly. *C. mastigophorus*
5. In lateral view dorsal lobe of seminal receptical arising from anterior edge of ventral lobe (fig. 20d); dorsal lobe not bulb shaped; the spiniform processes thick and not uniformly tapered from base. *C. arcuicornis*
   In lateral view dorsal lobe of seminal receptical bulb shaped, constricted in the region of attachment to ventral lobe; furcal ramus more than 1.52 times as long as wide first antennae segment 2 more than 1.40 times as long as segment 24. *C. brevipes*
   In lateral view dorsal lobe of seminal receptical bulb shaped, constricted in the region of attachment to ventral lobe; furcal ramus less than 1.52 times as long as wide first antennae segment 2 less than 1.40 times as long as segment 24. *C. parapergens*

Clausocalanus arcuicornis (Dana, 1849)
(figs 20a - e)

Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal (The occurrence in the Coastal and Oceanic waters was not determined due to the difficulties involved in identification).
Figure Explanations:
(a) female whole animal, lateral view,
(b) female rostrum,
(c) female second basipodite of third leg, posterior aspect,
(d) female last metasomal segment and genital segment, lateral view,
(e) female fifth leg.

Clausocalanus brevipes Frost and Fleminger, 1968
(figs 21a - e)

Reference Specimen: Frost, C.S.I.R.O., Cronulla, Bottle No. 39, Sample No. Thala Dan 5H.
Previous Tasmanian Records: Nil.
Occurrence: A few specimens (6 in number) identified were taken from only one station

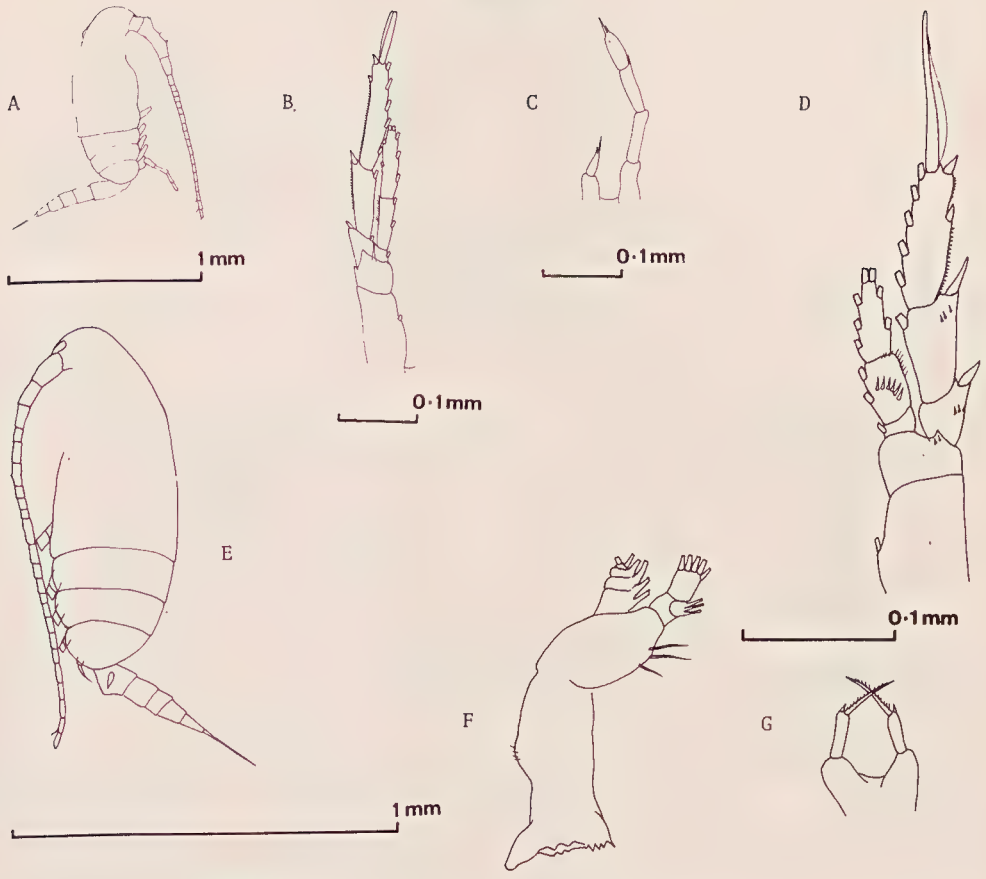


FIGURE 19

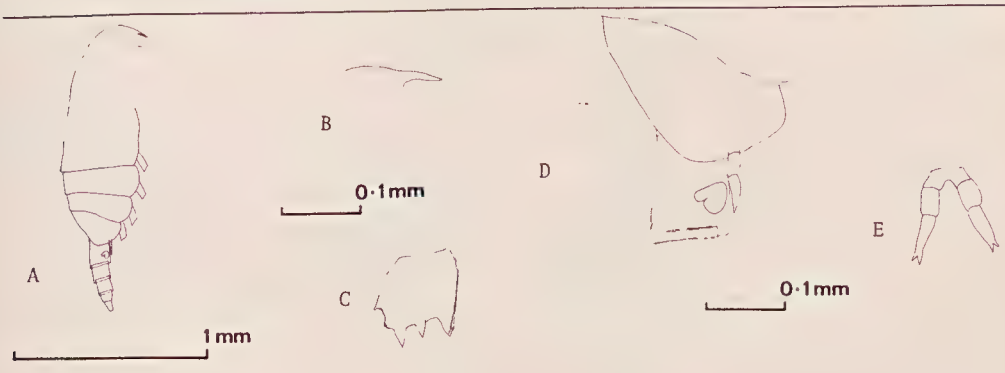


FIGURE 20

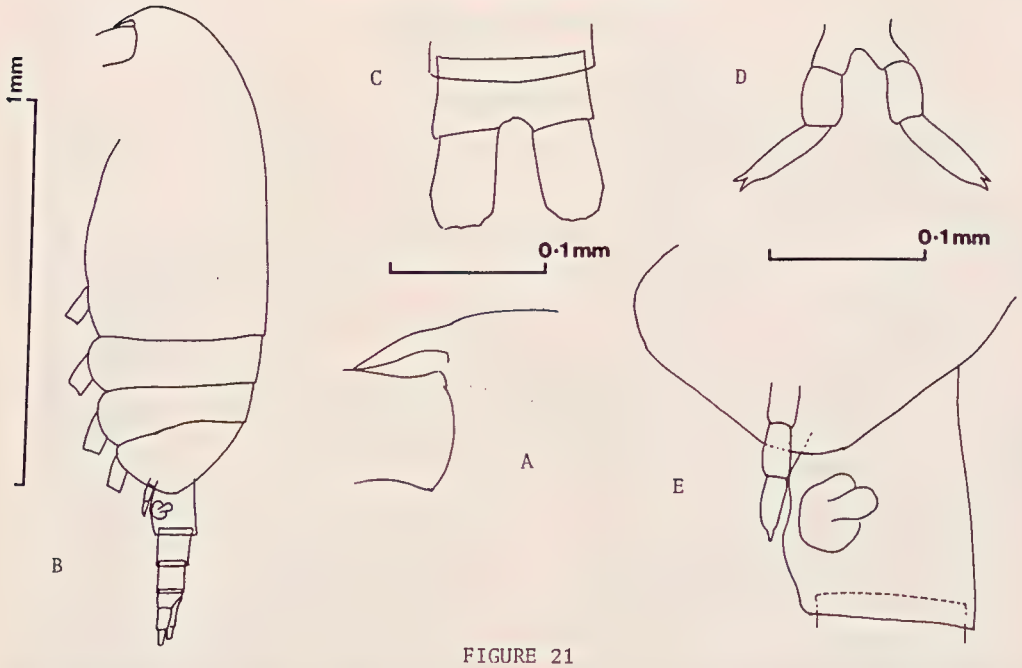


FIGURE 21

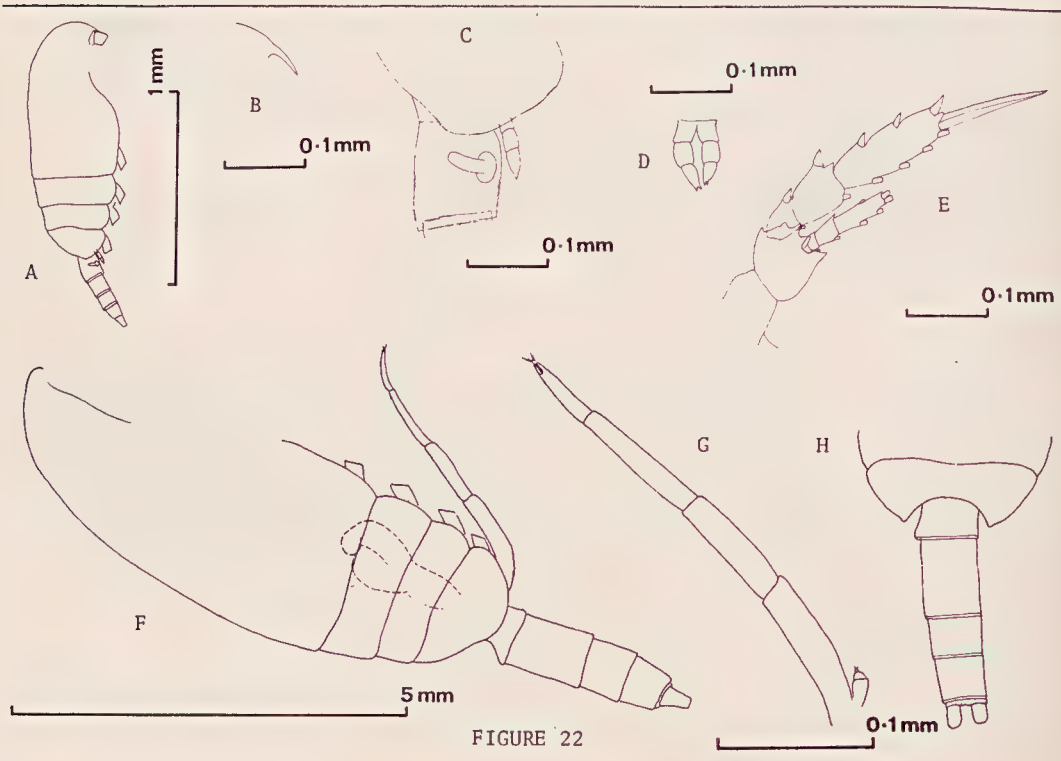


FIGURE 22

(St. E2, Nov. 1972). (The occurrence in the Coastal and Oceanic waters was not determined due to the difficulties involved in identification).
Figure Explanations:
(a) female rostrum, lateral view,
(b) female whole animal, lateral view,
(c) female furcal rami, dorsal view,
(d) female fifth leg,
(e) female last metasomal segment and genital segment, lateral view.

Clausocalanus ingens Frost and Fleminger, 1968
(figs 22a - h)

Reference Specimens: Frost, C.S.I.R.O., Cronulla, Bottle No. 38, Sample No. Thala Dan 5H.
Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, lateral view,
(b) female rostrum, lateral view,
(c) female last metasomal segment and genital segment, lateral view,
(d) female fifth leg,
(e) female third leg, posterior aspect,
(f) male whole animal, lateral view,
(g) male fifth leg,
(h) male last metasomal segment and urosome, dorsal view.

Clausocalanus jobei Frost and Fleminger, 1968
(figs 23a - c)

Reference Specimen: Frost, C.S.I.R.O., Cronulla, Bottle No. 39, Sample No. Patanela 2107E.
Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal. (The occurrence in the Coastal and Oceanic waters was not determined due to the difficulties involved in identification).
Figure Explanations:
(a) female whole animal, lateral view,
(b) female last metasomal segment and genital segment, lateral view,
(c) female fifth leg.

Clausocalanus laticeps Farran, 1929
(figs 24a - e)

Reference Specimen: Vervoort, C.S.I.R.O., Cronulla, Bottle No. 32, Sample No. Wm. Barondz A004.
Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort, 1957).
Occurrence: Coastal and Oceanic.
Figure Explanations:
(a) female anterior of the head, lateral view,
(b) female whole animal (another specimen), lateral view,
(c) female second basipodite of third leg, posterior aspect,
(d) female urosome, dorsal view,
(e) female fifth leg.

Clausocalanus mastigophorus (Claus, 1863)
(figs 25a - d)

Reference Specimen: Frost, C.S.I.R.O., Cronulla, Bottle No. 40, Sample No. 1133E.
Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal. (The occurrence in the Coastal and Oceanic waters was not determined due to the difficulties involved in identification).

Figure Explanations:
(a) female whole animal, lateral view,
(b) female second basipodite of third leg, posterior aspect,
(c) female last metasomal segment and genital segment, lateral view,
(d) female fifth leg.

Clausocalanus parapergens Frost and Fleminger, 1968
(figs 26a - e)

Reference Specimen: Frost, C.S.I.R.O., Cronulla, Bottle No. 41, Sample No. 1178E.
Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal. (The occurrence in the Coastal and Oceanic waters was not determined due to the difficulties involved in identification).
Figure Explanations:
(a) female first antenna,
(b) female whole animal, lateral view,
(c) female furcal rami, dorsal view,
(d) female fifth leg,
(e) female seminal recepticle, lateral view.

Ctenocalanus vanus Giesbrecht, 1888
(figs 27a - e)

Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal, Coastal and Oceanic.
Distribution: Off the French Coast (Rose 1933); Southeastern Australian waters (Dakin and Colefax 1933, 1940); off Kaikoura, New Zealand (Bradford 1970, 1972); Hauraki Gulf, New Zealand (Jillett 1971).
Figure Explanations:
(a) female whole animal, dorsal view,
(b) male whole animal, dorsal view,
(c) female fourth leg, posterior aspect,
(d) female lateral serrated spines of the third exopodite of the fourth leg,
(e) male fifth leg.

Family AETIDEIDAE

Aetideus pseudarmatus Bradford, 1971
(figs 28a - d)

Previous Tasmanian Records: Nil.
Occurrence: Station E9, November 1972 - 1 female.
Figure Explanations:
(a) female whole animal, lateral view,
(b) female last metasomal segment and genital segment, lateral view,
(c) female mandible,
(d) female fourth leg.

Chiridius gracilis Farran, 1908
(figs 29a - d)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort 1957).
Occurrence: Station E1, November, 1972 - 6 females.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female second leg,
(c) female fourth leg,
(d) mandible and palp.

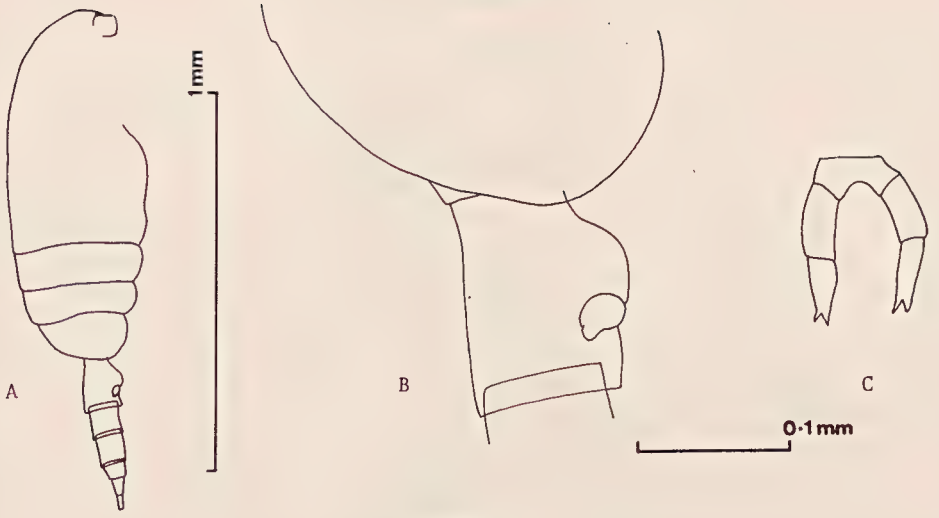


FIGURE 23

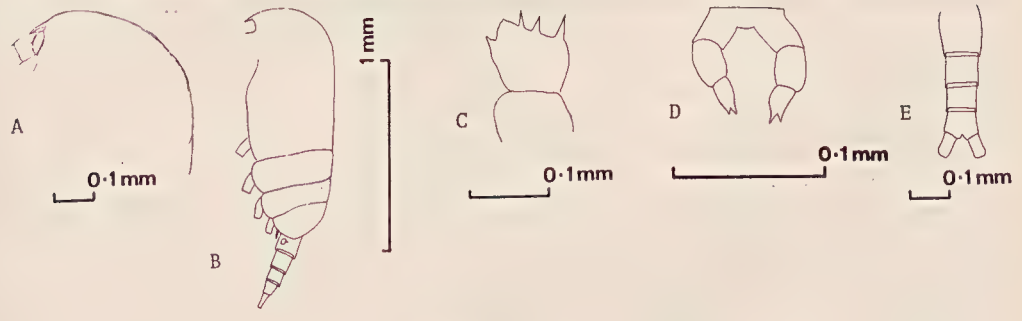


FIGURE 24

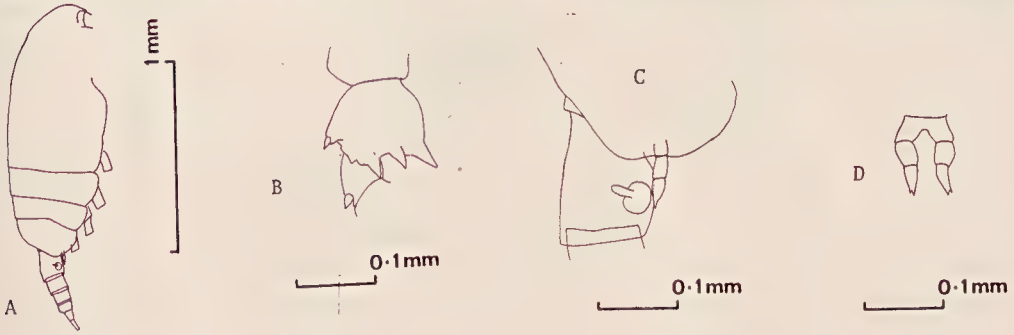


FIGURE 25

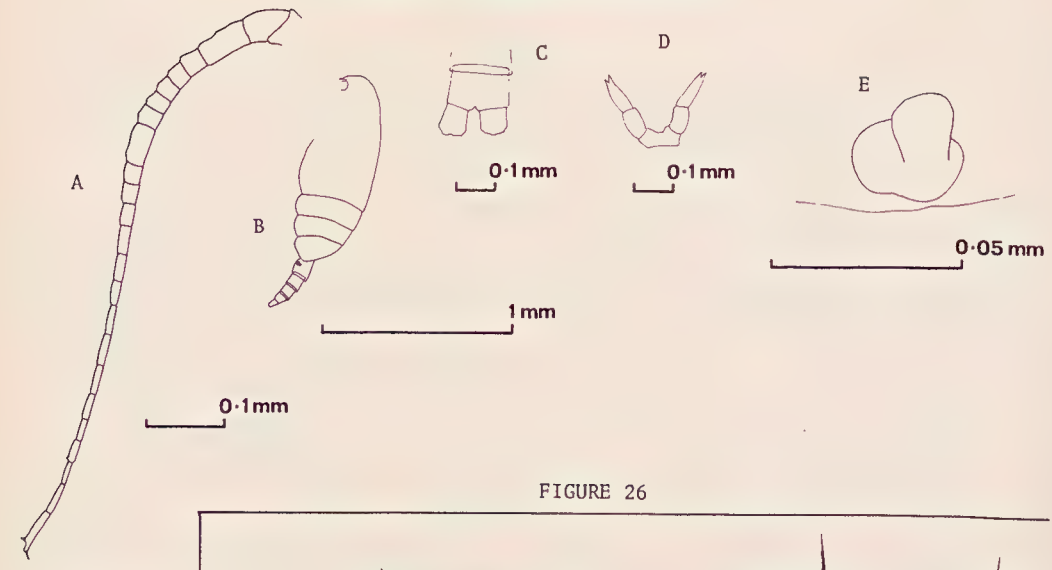


FIGURE 26

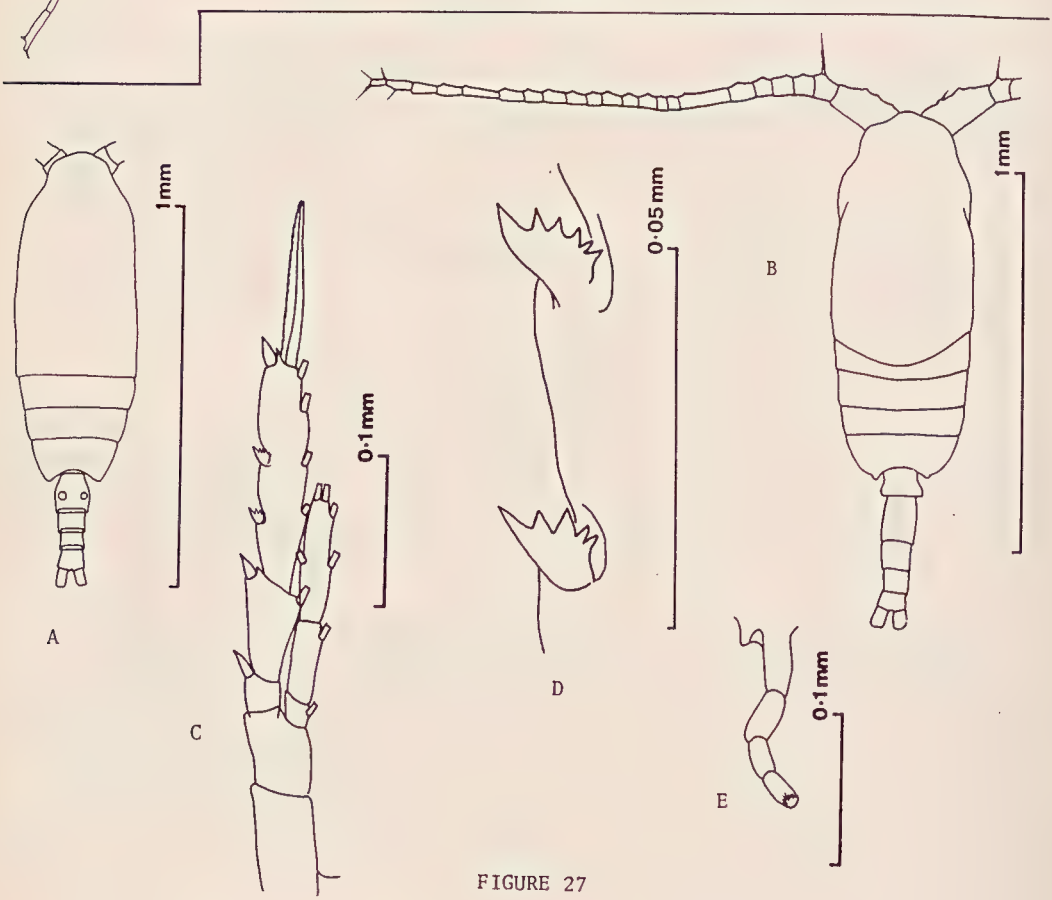


FIGURE 27

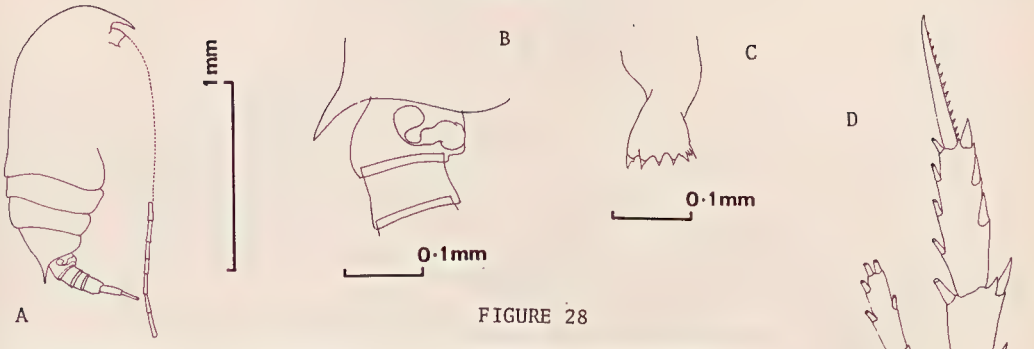


FIGURE 28

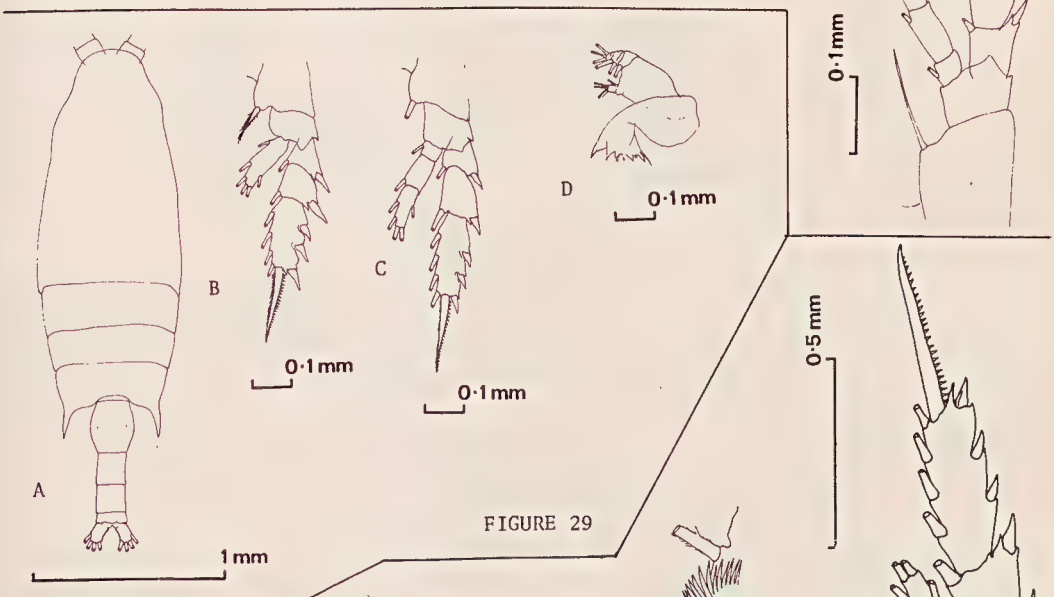


FIGURE 29

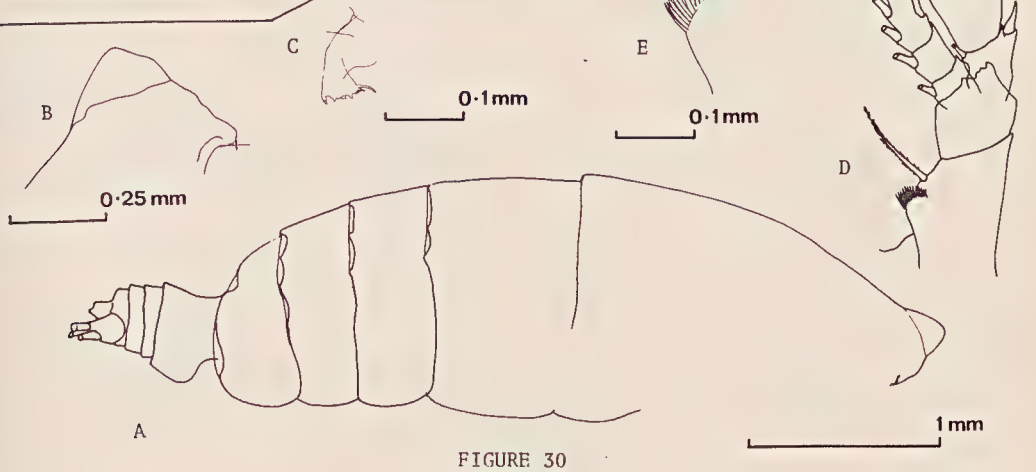


FIGURE 30

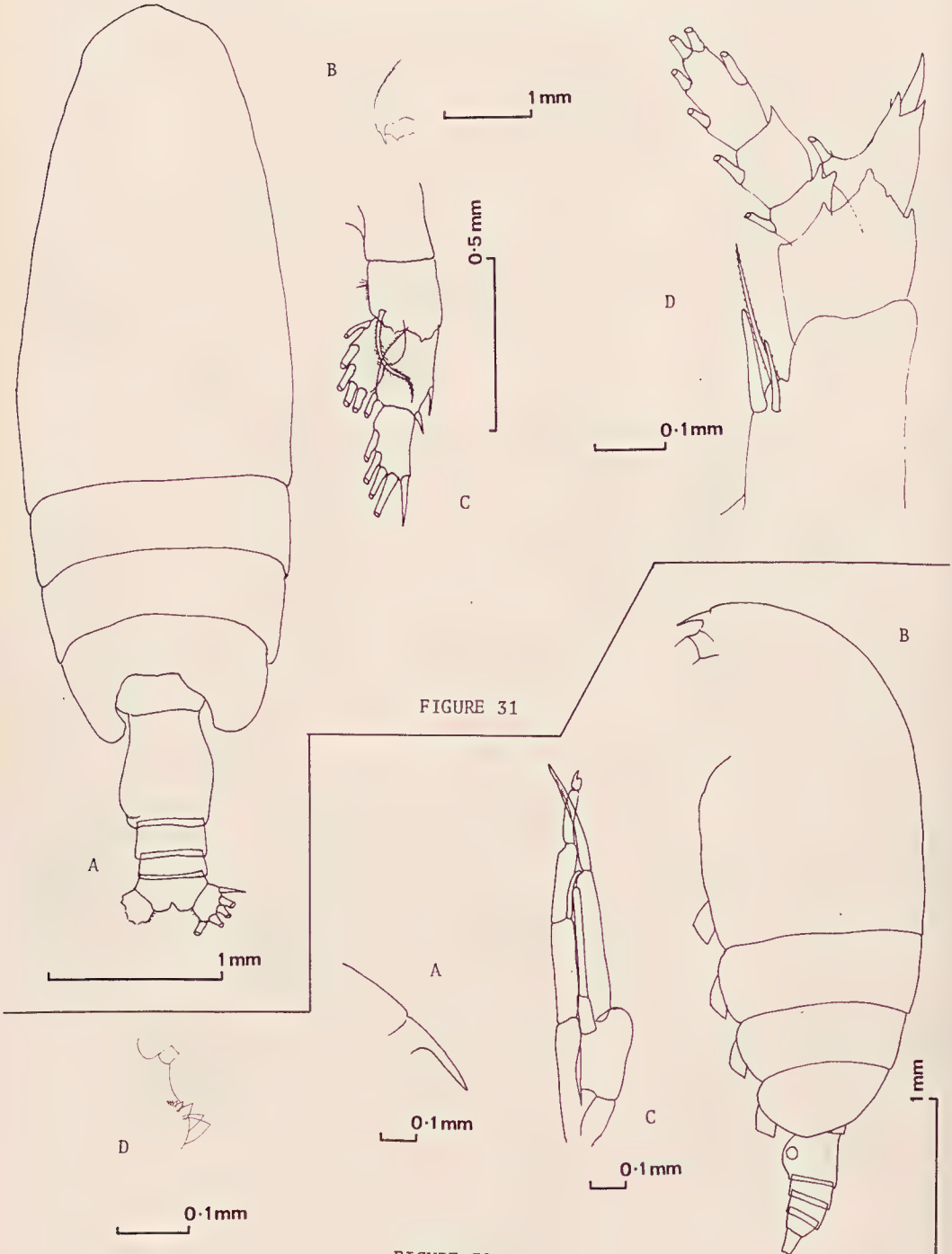


FIGURE 31

FIGURE 32

Nyan Taw

Euchirella curticauda Giesbrecht, 1888
(figs 30a - e)

Previous Tasmanian Records: Nil.
Occurrence: Station E6, May, 1973 - 1 female.
Figure Explanations:
(a) female whole animal, lateral view,
(b) female anterior region of head, lateral view,
(c) female mandible,
(d) female fourth leg, posterior aspect,
(e) inner region of first basal segment of female fourth leg, posterior aspect.

Euchirella formosa Vervoort, 1949
(figs 31a - d)

Previous Tasmanian Records: Nil.
Occurrence: Station E6, May, 1973 - 1 female.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female anterior region of head, lateral view,
(c) female first leg,
(d) female fourth leg, posterior aspect (without middle and distal segments of exopodite).

Euchirella rostrata (Claus)
(figs 32a - d)

Reference Specimen: Hammick and Fleminger, C.S.I.R.O., Cronulla, Bottle No. 19, Sample No. South Coast N.S.W.
Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort 1957).
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) female rostrum,
(b) female whole animal, lateral view,
(c) male fifth leg,
(d) female first basal segment of the fourth leg, posterior aspect.

Euchirella rostromagna (Wolfenden, 1911)
(figs 33a - d)

Reference Specimen: Vervoort, C.S.I.R.O., Cronulla, Bottle No. 31, Sample No. Wm Barends A029.
Previous Tasmanian Records: Nil.
Occurrence: Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, lateral view,
(b) female rostrum, lateral view,
(c) female first basal segment of the fourth leg, posterior aspect,
(d) female fourth leg, posterior aspect.

Euchirella venusta Giesbrecht, 1892
(figs 34a - e)

Previous Tasmanian Records: Nil.
Occurrence: Station E11, January, 1972 - 1 female.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female anterior region of head, lateral view,
(c) female last metasomal segment and urosome, lateral view,
(d) female fourth leg, posterior aspect,
(e) inner region of first basal segment of female fourth leg, posterior aspect.

Euchirella sp.
(figs 35a - e)

Previous Tasmanian Records: Nil.
Occurrence: Station E 7, November, 1971 - 1 female.
Remarks: The male fifth legs of the present specimen generally resembles the fifth legs of the known species of *Euchirella*. The right leg is very similar in structure to the right leg of *E. messinensis*. However, as with other species of the genus *Euchirella*, the main character which differs is the structure of the terminal part of the 5th leg. In the present specimen the outer segment of the terminal part is claw-like (fig. 35e) in appearance.
Figure Explanations:

(a) male whole animal, lateral view,
(b) male rostrum, lateral view,
(c) terminal portion of male left fifth leg,
(d) male fifth leg,
(e) terminal portion of male right fifth leg.

Undeuchaeta plumosa (Lobbock, 1856)
(figs 36a - d)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort 1957).
Occurrence: Coastal and Oceanic.
Figure Explanations:

(a) female whole animal, dorsal view,
(b) male fifth leg,
(c) female last metosomal segment and genital segment, dorsal view,
(d) male whole animal, dorsal view.

Family EUCHAETIDAE

Euchaeta acuta Giesbrecht, 1892
(figs 37a - l)

Previous Tasmanian Records: Nil.
Occurrence: Station E 11, December, 1971 - 8 females, 1 male
Station E 12, December, 1971 - 1 female, 1 male
Station E 7, November, 1972 - 4 females
Station E 6, May, 1973 - 1 male
Figure Explanations:

(a) female whole animal, dorsal view,
(b) female genital segment, lateral view,
(c) exopodite of female fourth leg,
(d) rostrum, lateral view,
(e) exopodite of female first leg,
(f) apical spine of the second maxilla,
(g) male whole animal, dorsal view,
(h) male furcal rami, dorsal view,
(i) male rostrum, lateral view,
(j) male fifth leg,
(k) portion of distal segments of male left fifth leg,
(l) portion of distal segment of male left fifth leg. (another specimen).

Family PHAENNIDAE

Phaenna spinifera Claus, 1863
(figs 38a - d)

Previous Tasmanian Records: Nil.
Occurrence: Station E 5, May, 1973 - 1 female.

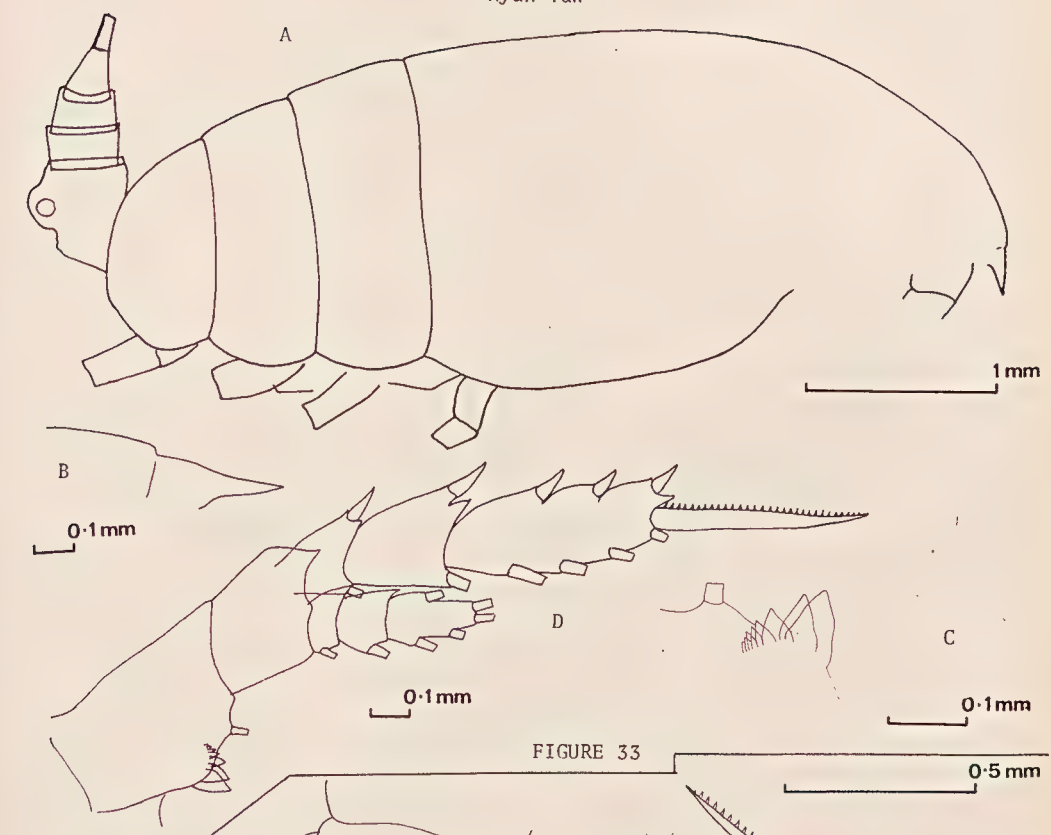


FIGURE 33

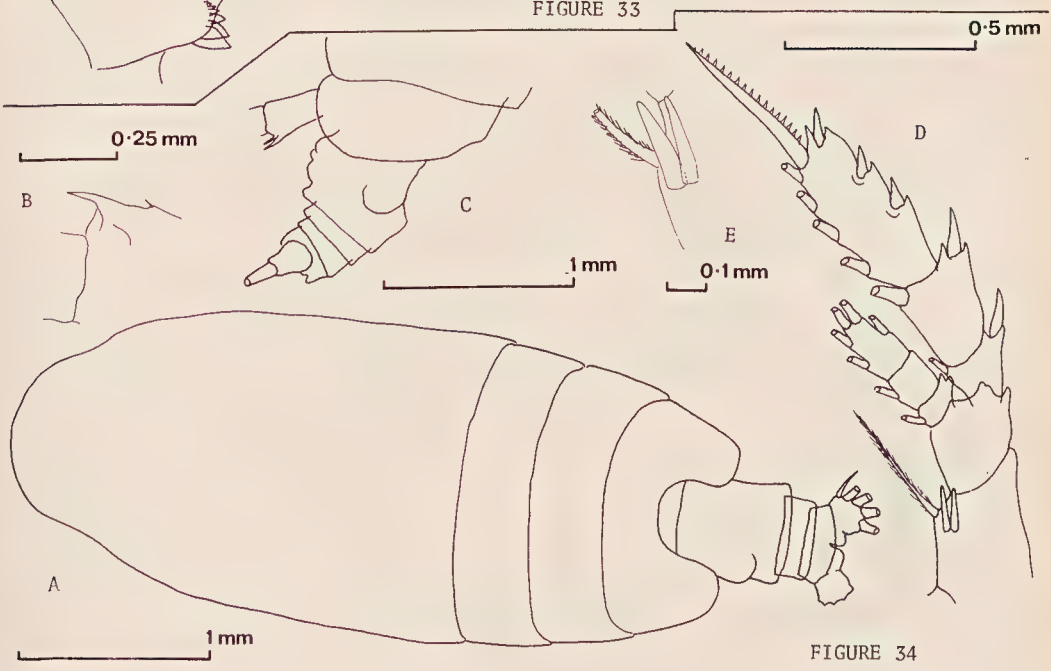


FIGURE 34

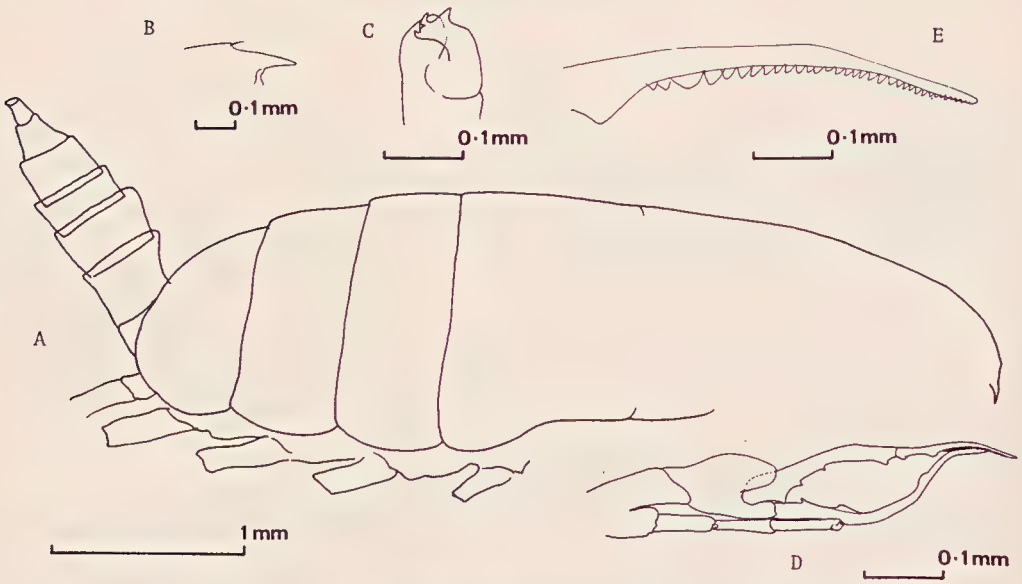


FIGURE 35

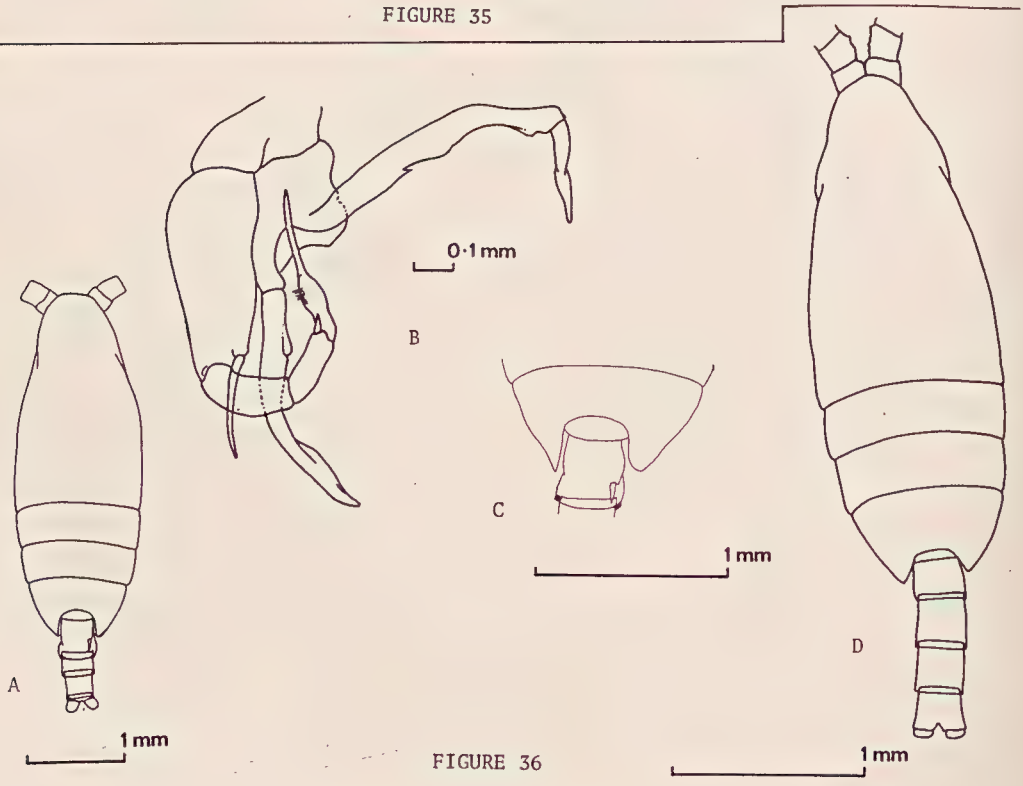


FIGURE 36

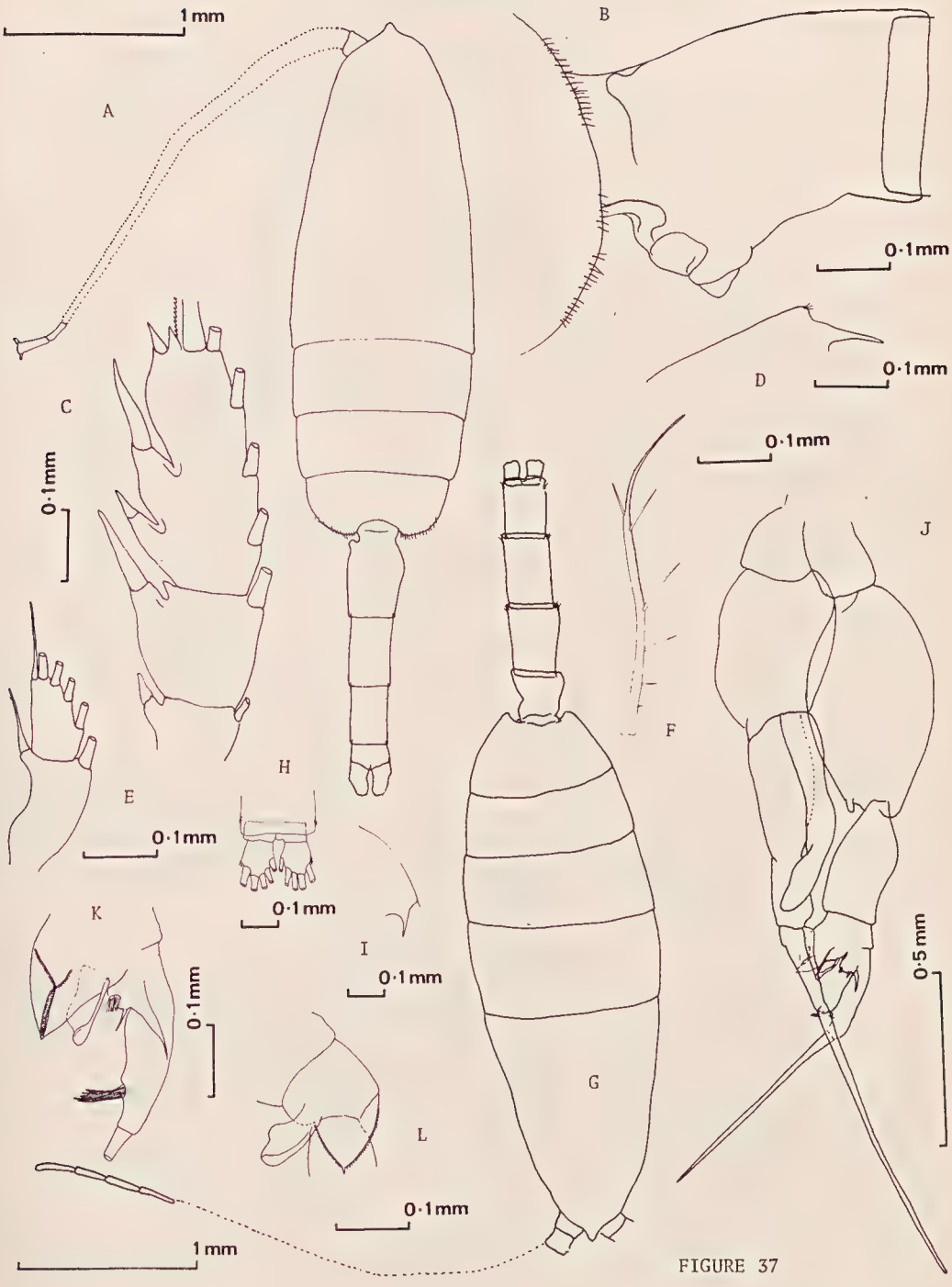

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FIGURE 37

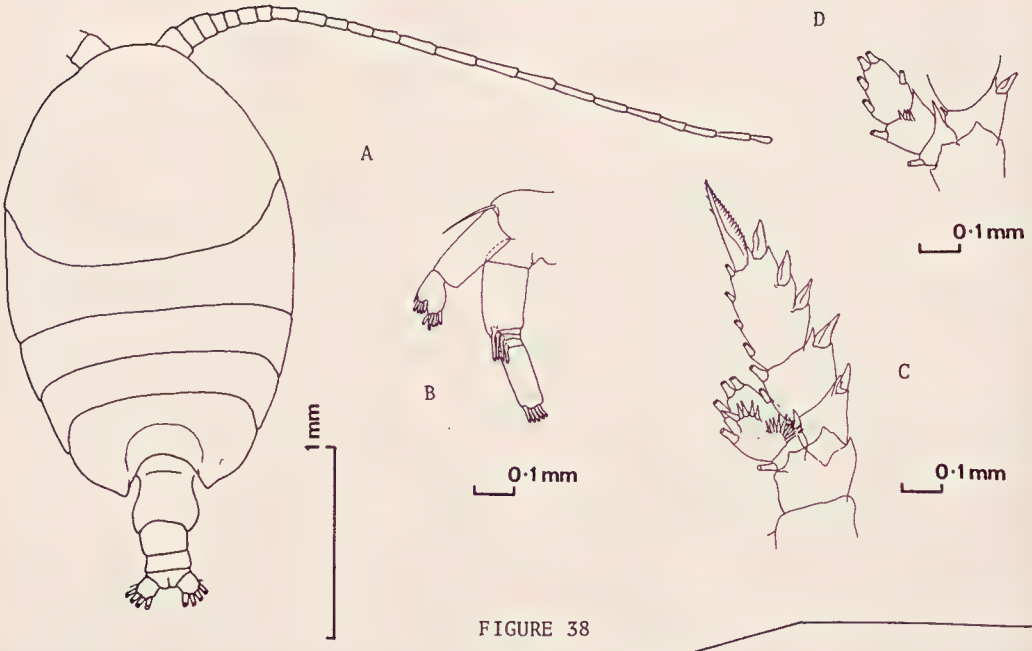


FIGURE 38

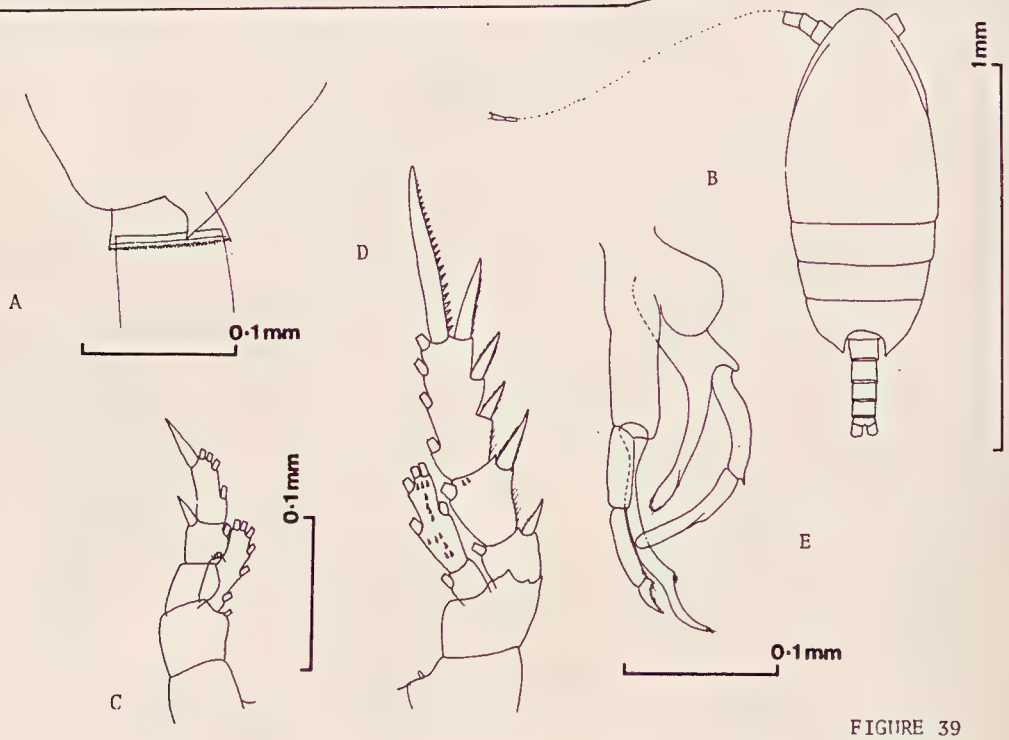


FIGURE 39

Figure Explanations:
(a) female whole animal, dorsal view,
(b) female second antenna,
(c) female second leg, posterior aspect,
(d) endopod and proximal exopodite segment of female fourth leg, posterior aspect.

Family SCOLECITHRICIDAE

Racovitzanus sp.
(figs 39a - e)

Previous Tasmanian Records: Nil.
Occurrence: Station IC 3, December, 1971, midwater night plankton tow - 1 male.
Figure Explanations:
(a) male posterior boarder of last metasomal segment and lateral view,
(b) male whole animal, dorsal view,
(c) male first leg, posterior aspect,
(d) male second leg, posterior aspect,
(e) male fifth leg.

Scolecithrix bradyi Geisbrecht
(figs 40a - c)

Previous Tasmanian Records: Nil.
Occurrence: Station E 7, November, 1971 - 3 females
Station E 12, November, 1971 - 1 male
Station E 2, November, 1972 - 1 female
Figure Explanations:
(a) male whole animal, dorsal view,
(b) male fifth leg,
(c) female whole animal, lateral view.

Scolecithrix danae (Lubbock, 1856)
(figs 41a - d)

Previous Tasmanian Records: Nil.
Occurrence: Station E 9, October, 1972 - 1 male and 1 female.
Figure Explanations:
(a) male whole animal, dorsal view,
(b) male fifth leg,
(c) female posterior region of metasome and urosome, lateral view.

Family CENTROPAGIDAE

Boeckella triarticulata (Thomson, 1883)
(figs 42a - f)

Previous Tasmanian Records: Freshwater Lakes and Lagoons of Tasmania (Bayly 1964)
Figure Explanations:
(a) female whole animal, lateral view,
(b) male last metasomal segment and urosome, dorsal view,
(c) female fourth leg,
(d) process on the middle exopodite segment of female fourth leg,
(e) male fifth leg,
(f) inner region of second basal segment of male fifth leg and endopodite.

Centropages australiensis Fairbridge, 1944
(figs 43a - d)

Previous Tasmanian Records: Mouth of River Derwent (Ong 1967).
Occurrence: Inshore coastal, Coastal and Oceanic.

Figure Explanations:
(a) female whole animal, dorsal view,
(b) male last metasomal segment and urosome, dorsal view,
(c) male right fifth leg,
(d) female fifth leg.

Centropages bradyi (Wheeler, 1899)
(figs 44a - c)

Previous Tasmanian Records: South of Tasmania 44°05'S, 147°35'E (Vervoort 1957).
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) male right fifth leg,
(c) female fifth leg.

Gladioferens inermis Nicholls, 1944
(figs 45a - h)

Previous Tasmanian Records: Nil.
Occurrence: Estuarine, Inshore coastal.
Figure Explanations:
(a) male whole animal, lateral view,
(b) male fifth leg,
(c) male second leg,
(d) male right first and second exopodite,
(e) female whole animal, dorsal view,
(f) female urosome, ventral view,
(g) female fifth leg,
(h) female fourth leg.

Gladioferens pectinatus (Brady, 1883)
(figs 46a - h)

Previous Tasmanian Records: River Derwent estuary (Nicholls 1956, Ong 1967).
Occurrence: Estuarine, Inshore coastal.
Figure Explanations:
(a) male whole animal, dorsal view,
(b) male fifth leg,
(c) inner junction of proximal and middle segments of exopodite of male right
(d), (e) fifth leg - variation in form of distal projection,
(f) female whole animal, lateral view,
(g) female fifth leg,
(h) female urosome ventral view.

Gladioferens spinosus Henry, 1922
(figs 47a - e)

Previous Tasmanian Records: Big Lake Waterhouse (Brehm, 1953).
Occurrence: Estuarine.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) posterior portion of metasome and genital segment of female, dorsal view,
(c) male last metasomal segment and urosome, dorsal view,
(d) male fifth leg,
(e) process on the inner proximal exopodite segment of male right fifth leg.

Gladioferens symmetricus Bayly, 1963
(figs 48a - d)

Previous Tasmanian Records: Nil.
Occurrence: Mouth of North West Bay River, D'Entrecasteaux Channel.

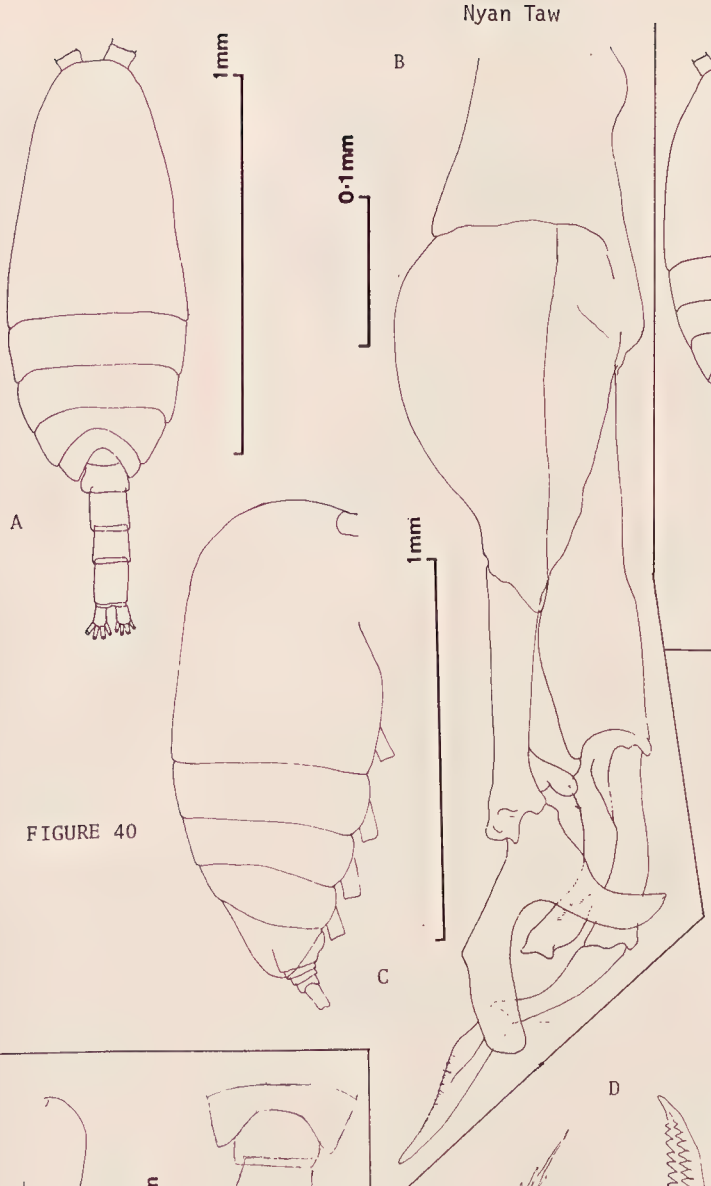


FIGURE 40

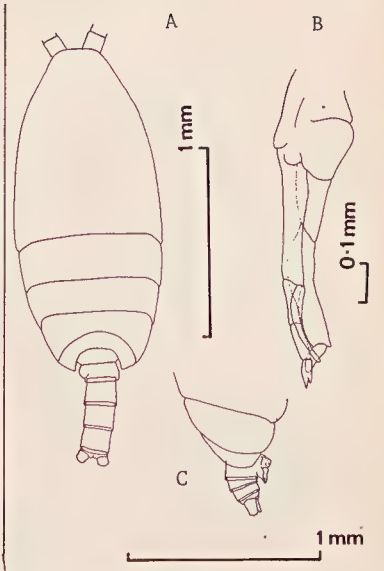


FIGURE 41

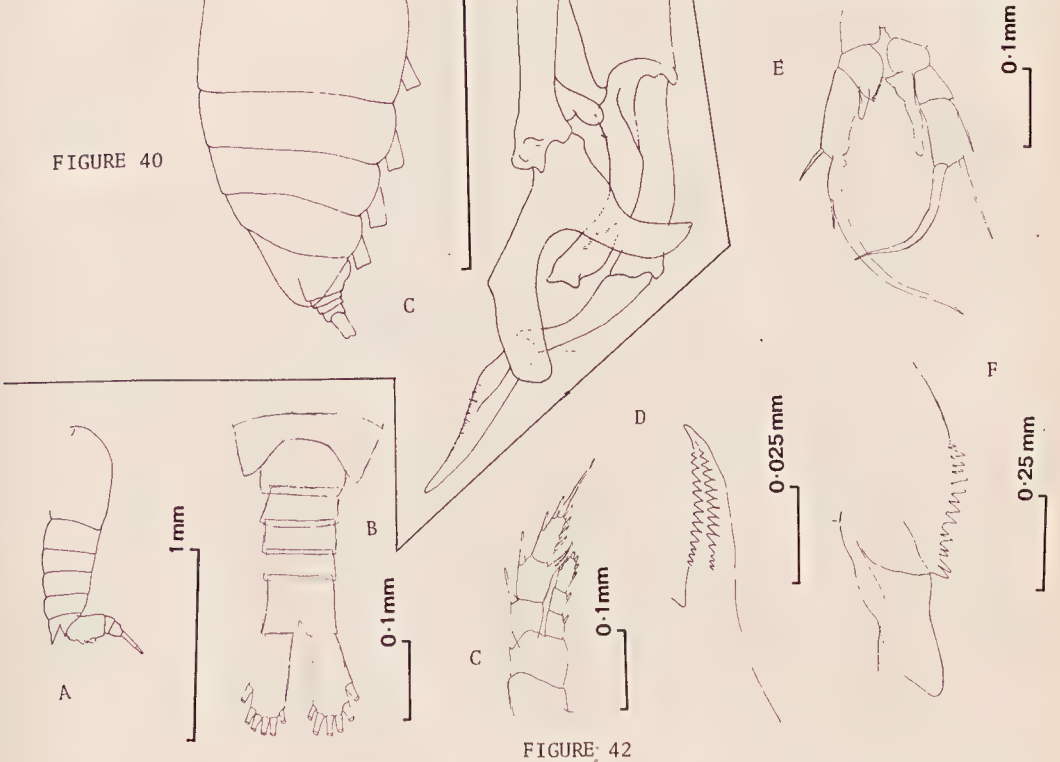


FIGURE 42

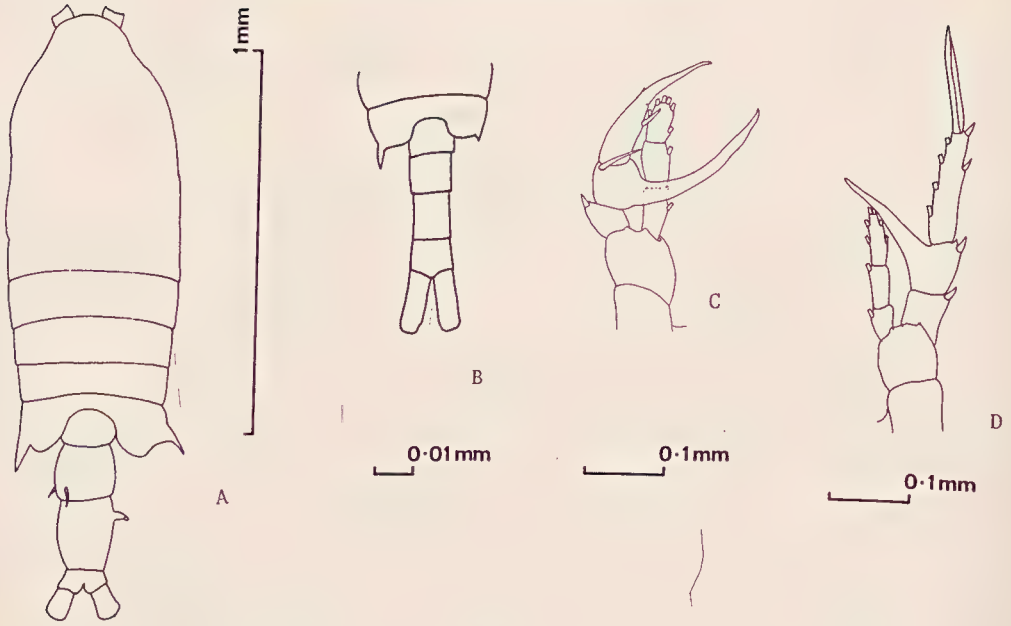


FIGURE 43

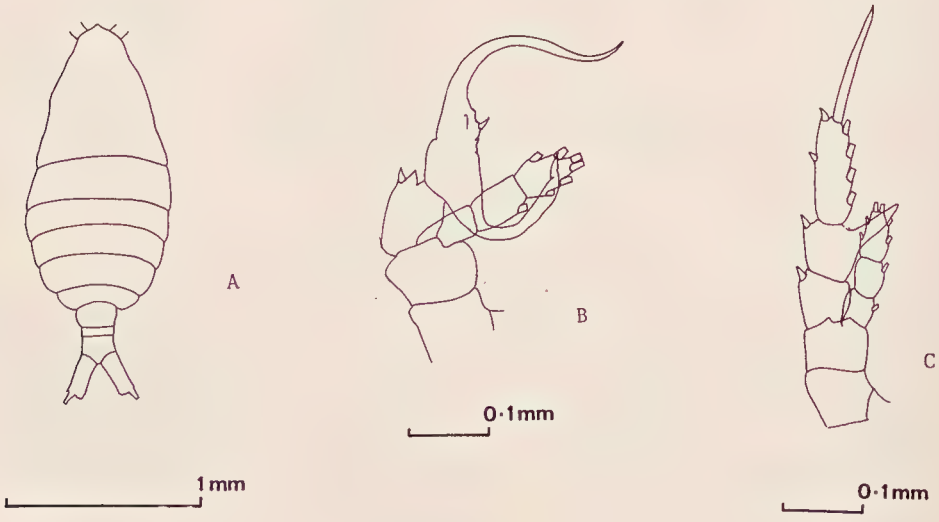


FIGURE 44

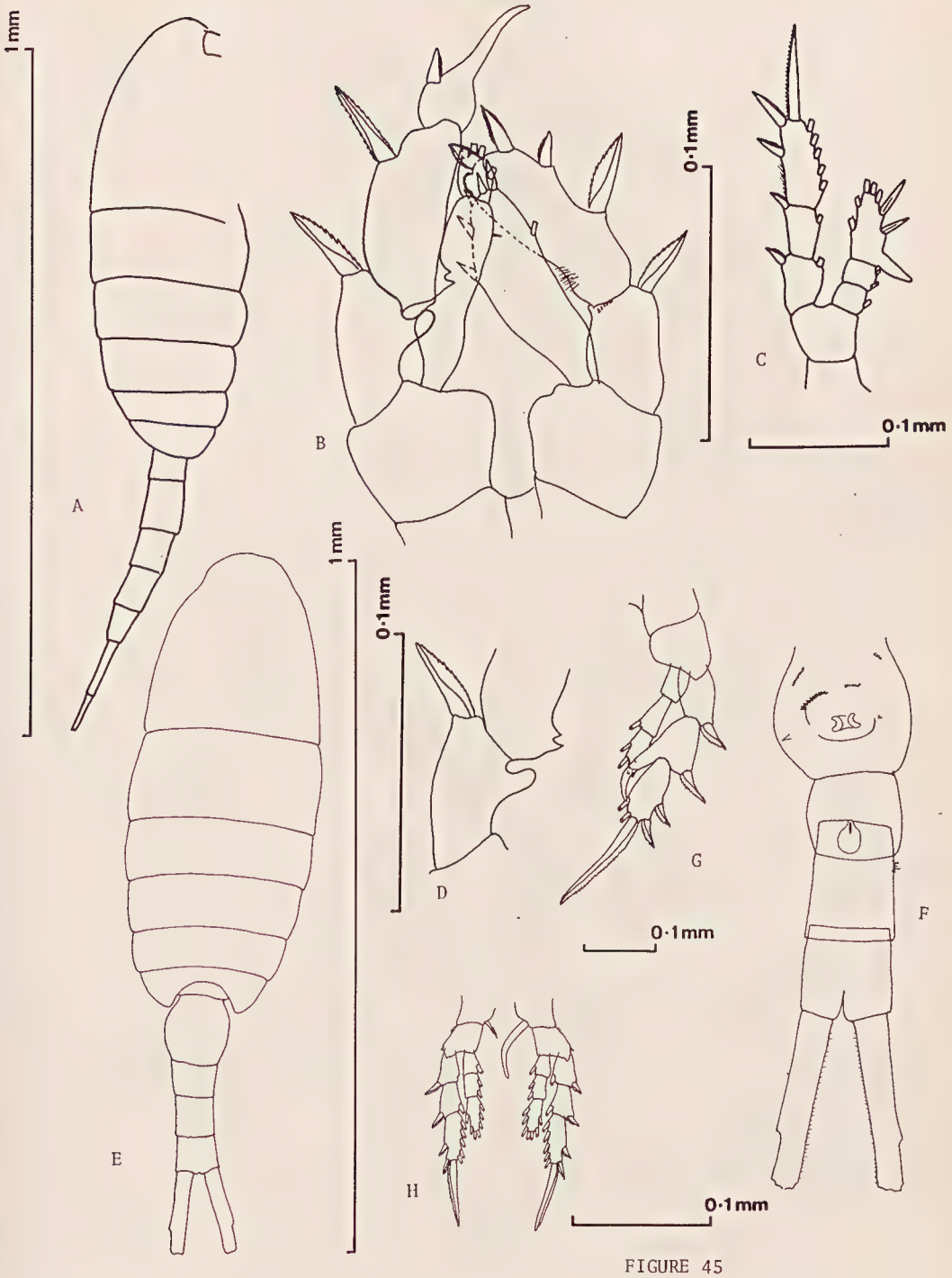


FIGURE 45

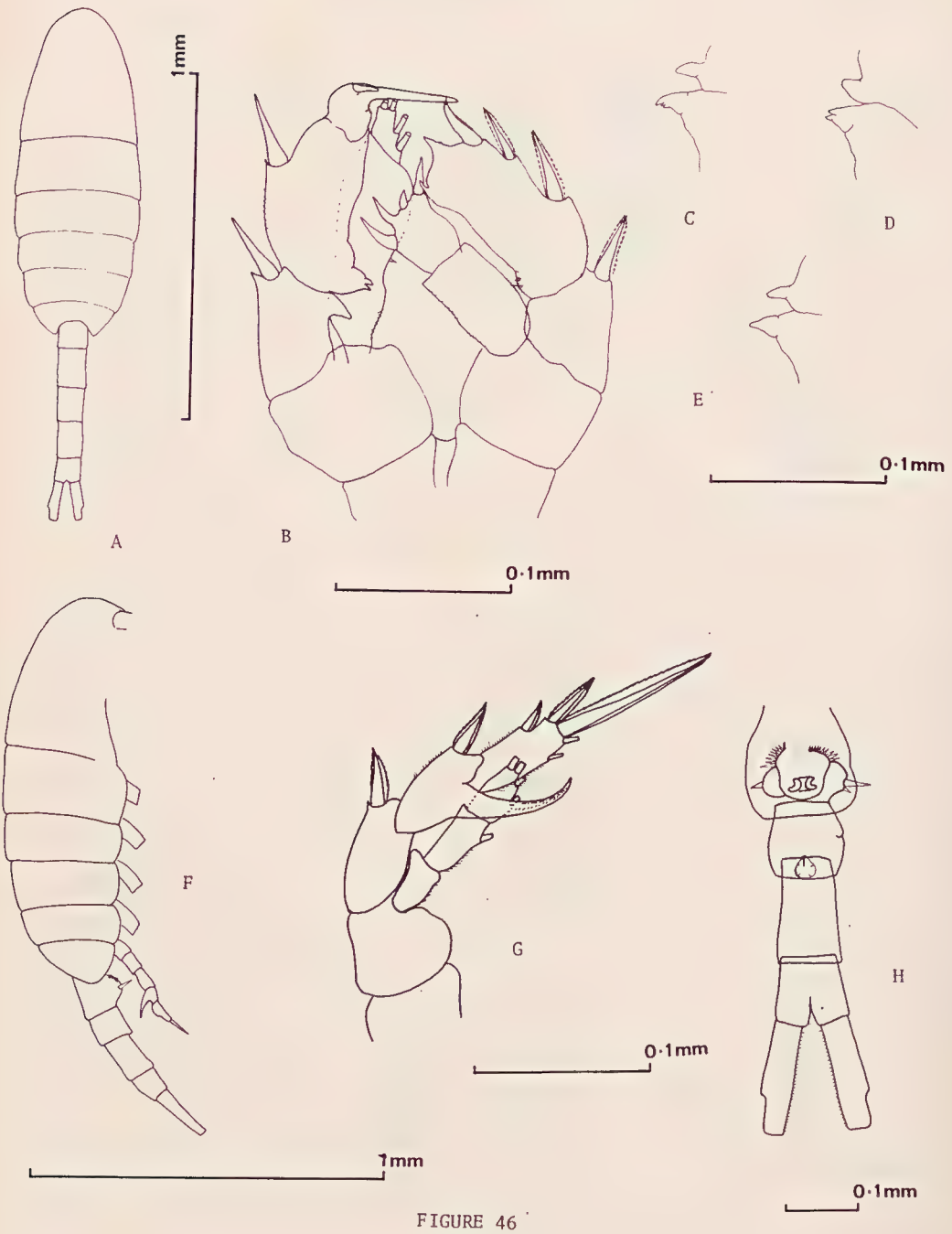


FIGURE 46

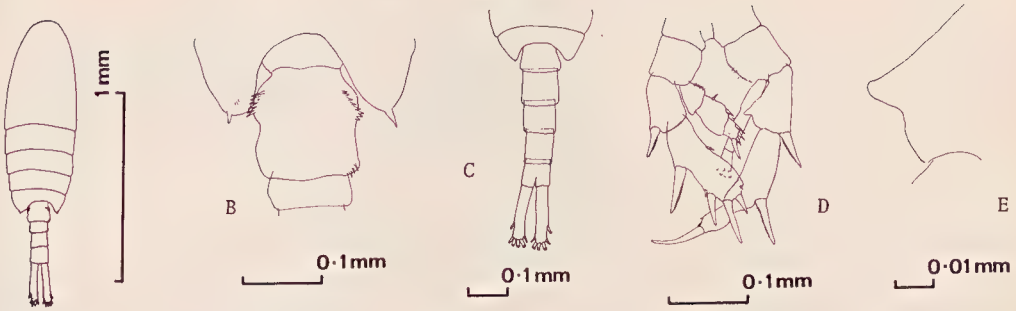


FIGURE 47

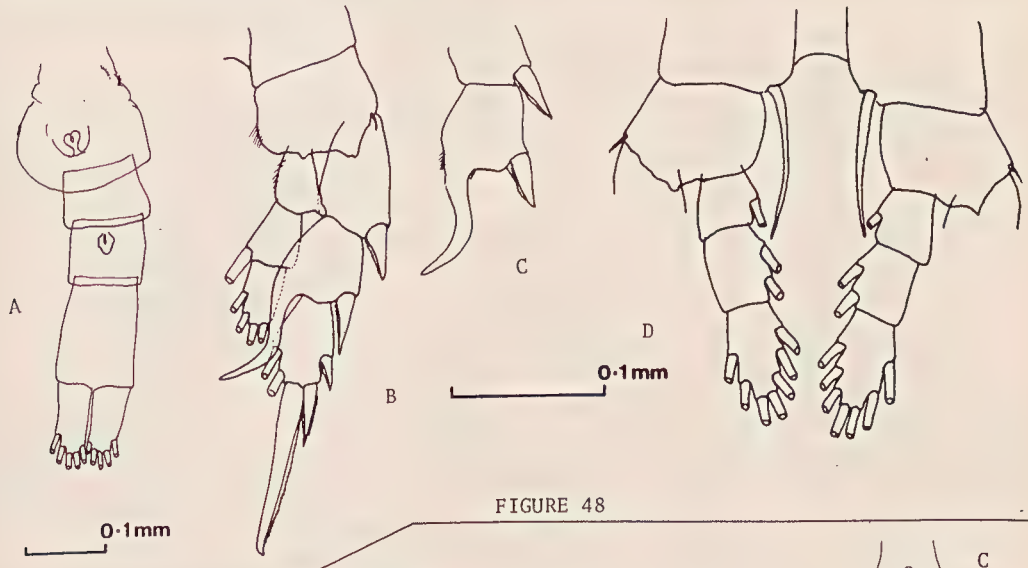


FIGURE 48

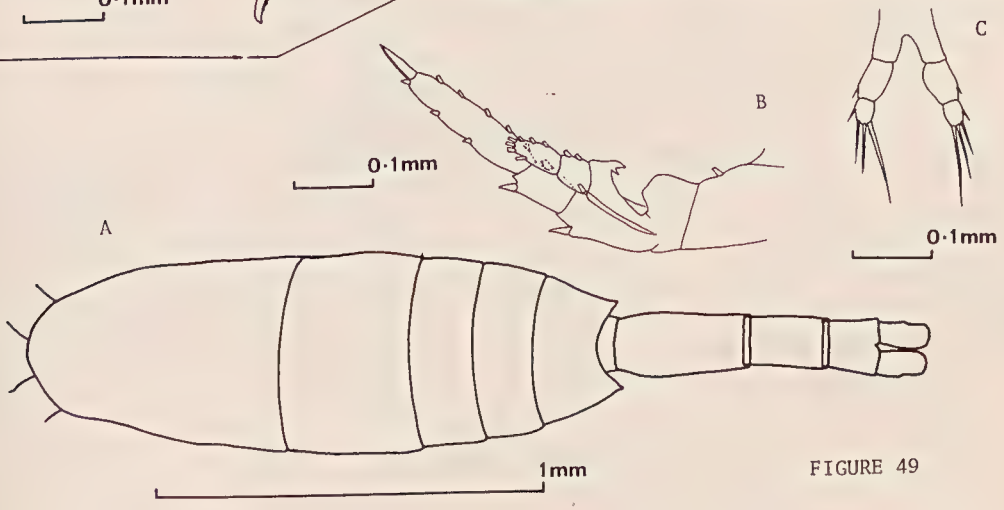


FIGURE 49

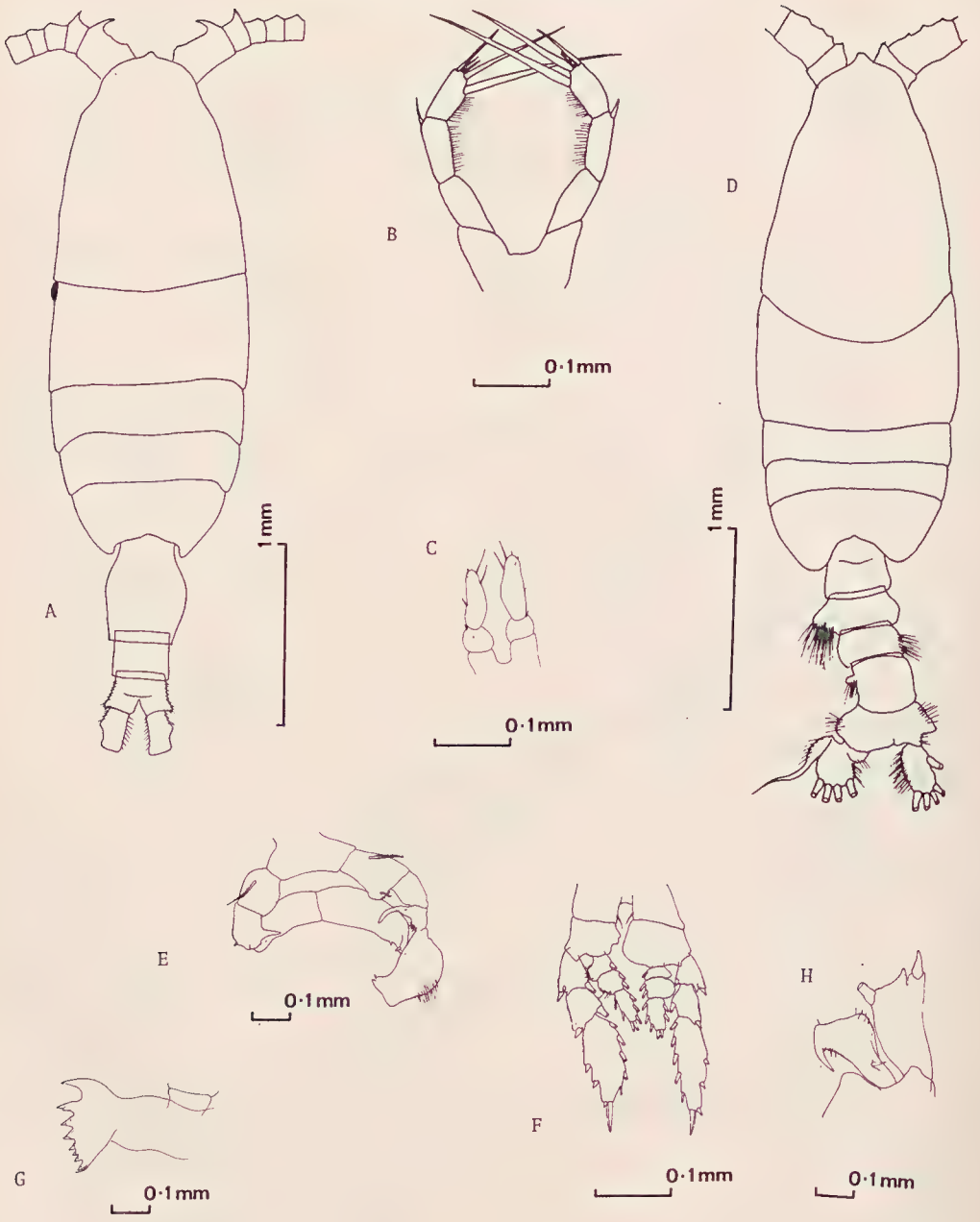


FIGURE 50

Figure Explanations:
(a) female urosome, ventral view,
(b) female fifth leg,
(c) middle exopodite segment of female fifth leg,
(d) female second leg without expodite.

Family METRIDIIDAE

Metridia lucens (Boeck, 1863)
(figs 49a - c)

Previous Tasmanian Records: Nil.
Occurrence: Station IC 3, June, 1972 - 1 female.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female second leg, posterior aspect,
(c) female fifth leg.

Pleuromamma abdominalis (Lubbock, 1856)
(figs 50a - h)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort 1957).
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fifth leg,
(c) immature female fifth leg,
(d) male whole animal, dorsal view,
(e) male fifth leg,
(f) male fourth leg,
(g) male mandible,
(h) proximal segments of male right second leg.

Pleuromamma gracilis (Claus, 1893)
(figs 51a - d)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort 1957).
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female genital segment, lateral view,
(c) female fifth leg,
(d) male fifth leg.

Pleuromamma xiphias (Giesbrecht, 1889)
(figs 52a - f)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort 1957).
Occurrence: Station E 6, May, 1973 - 6 males.
Figure Explanations:
(a) male whole animal, lateral view,
(b) male urosome, dorsal view,
(c) anterior region of male head, lateral view,
(d) proximal segments of male right first antenna,
(e) male fifth leg,
(f) male right second leg with part of left leg.

Family TEMORIDAE

Temora turbinata (Dana)
(figs 53a - d)

Previous Tasmanian Records: Nil.
Occurrence: Station E 9, October, 1972 - 2 females
Station E 10, October, 1972 - 2 feamels, 1 male.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) male fifth legs,
(c) female fifth legs,
(d) female fourth leg, posterior aspect.

Family PSEUDODIAPTOMIDAE

Pseudodiaptomus cornutus Nicholls, 1944
(figs 54a - g)

Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal.
Figure Explanations:
(a) male whole animal, lateral view,
(b) male right first antenna,
(c) male fifth leg,
(d) female whole animal, lateral view,
(e) female fifth legs,
(f) female last metasomal segment and genital segment,
(g) female fourth leg, posterior aspect.

Family LUCICUTIIDAE

Lucicutia flavicornis (Claus, 1863)
(figs 55a - c)

Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fifth leg,
(c) male fifth leg.

Family HETERORHABDIDAE

Heterorhabdus pappilliger (Claus, 1863)
(figs 56a - e)

Previous Tasmanian Records: Nil.
Occurrence: Inshore Coastal, Coastal and Oceanic.
Figure Explanations:
(a) male whole animal, dorsal view,
(b) male fifth leg,
(c) female posterior region of metasome and urosome, lateral view,
(d) female second maxilla,
(e) female fifth leg.

Family CANDACIIDAE

Candacia armata (Boeck, 1863)
(figs 57a - e)

Previous Tasmanian Records: Nil.

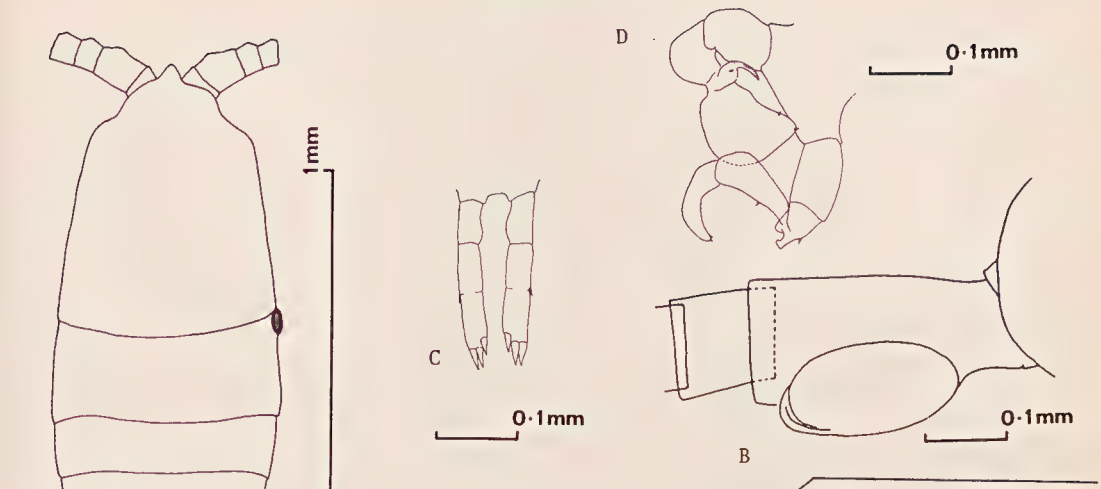


FIGURE 51

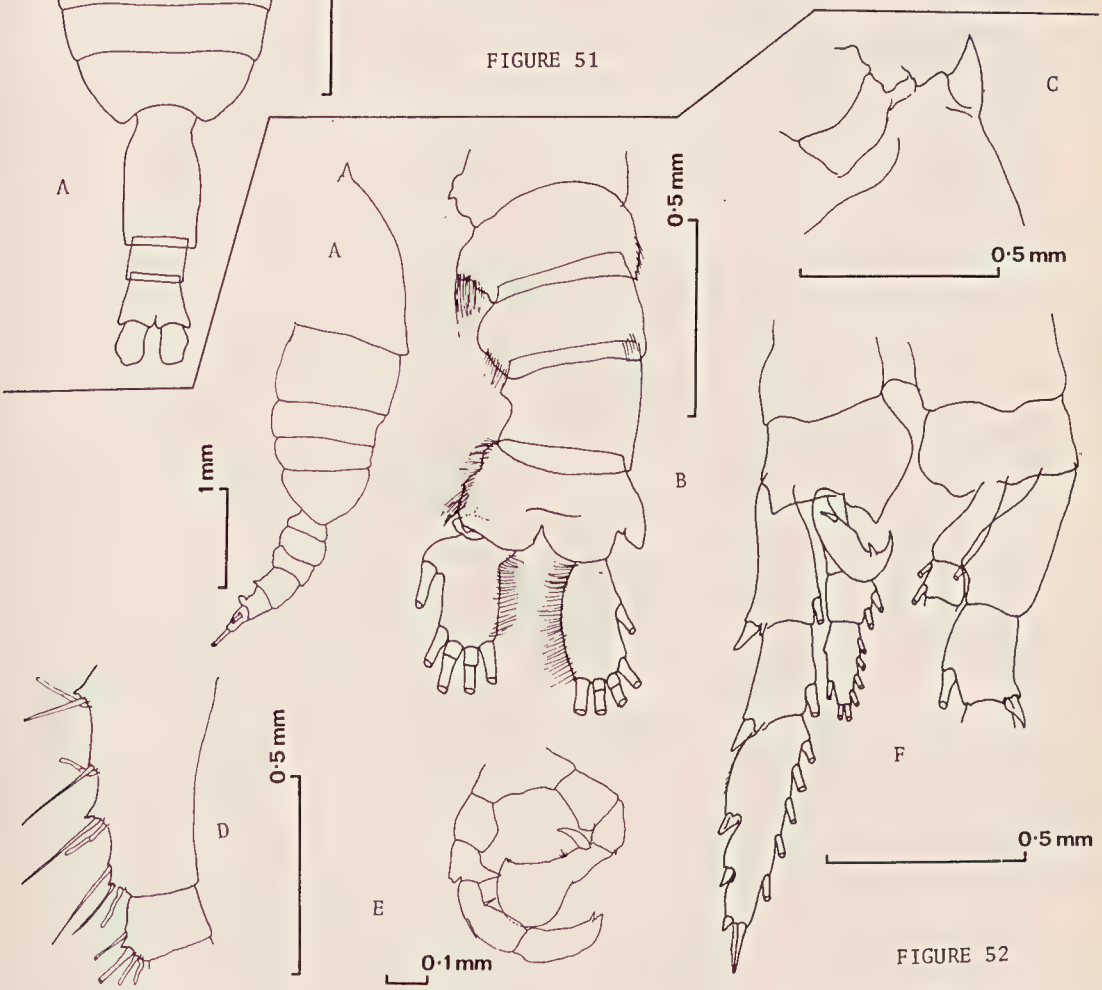


FIGURE 52

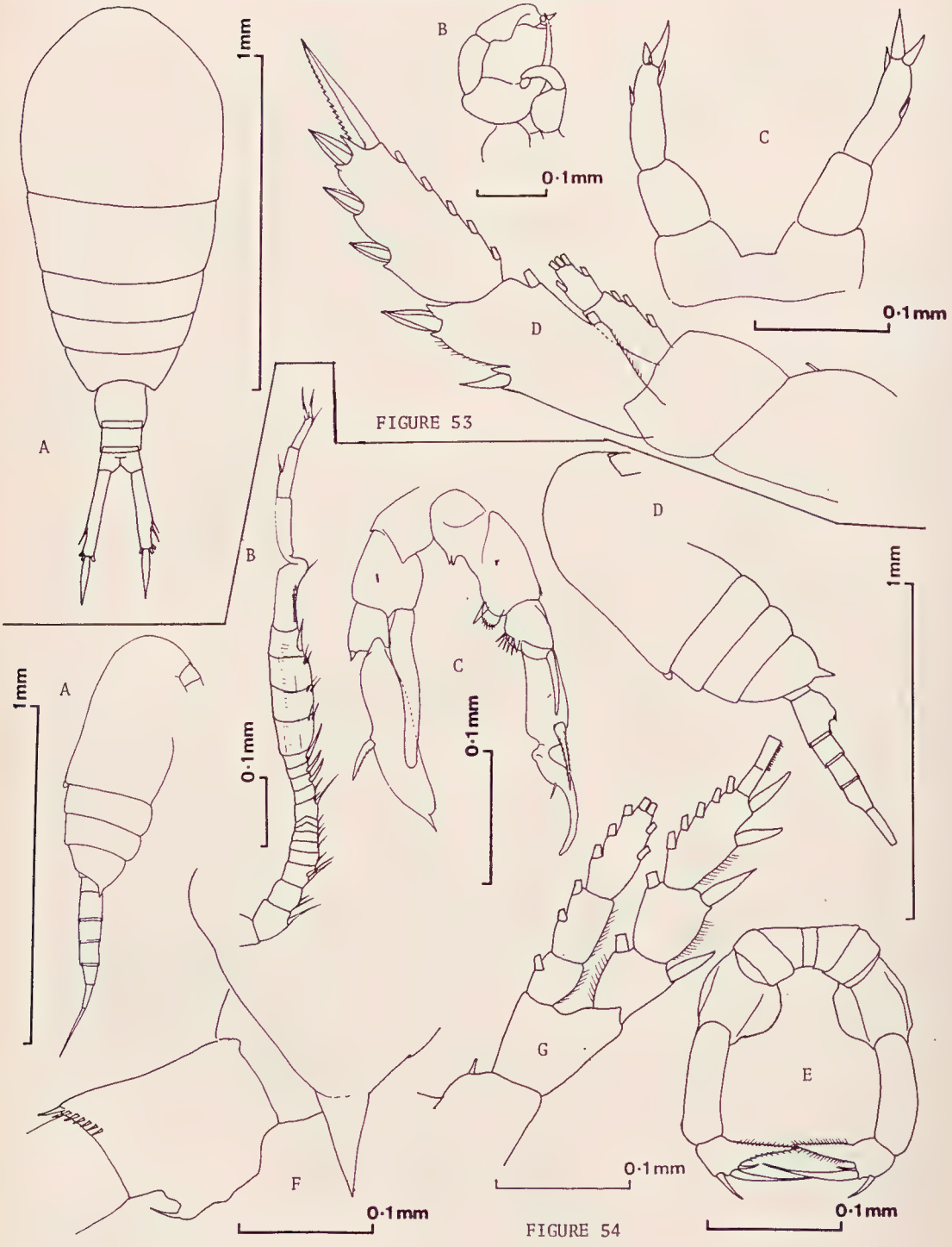


FIGURE 53

FIGURE 54

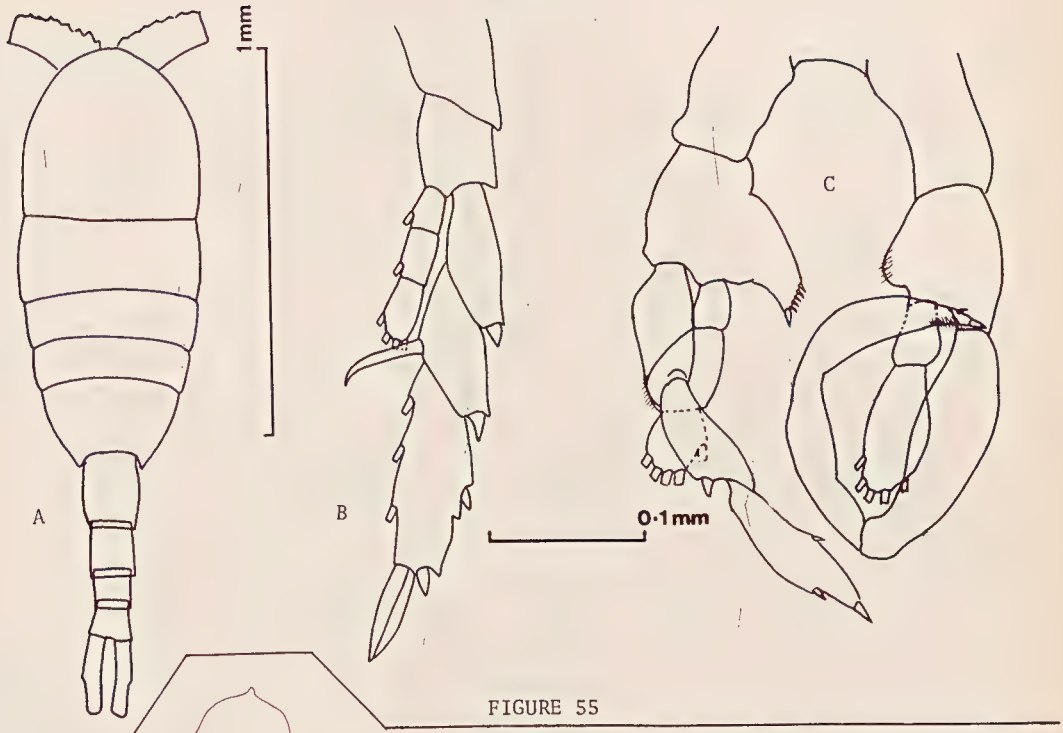


FIGURE 55

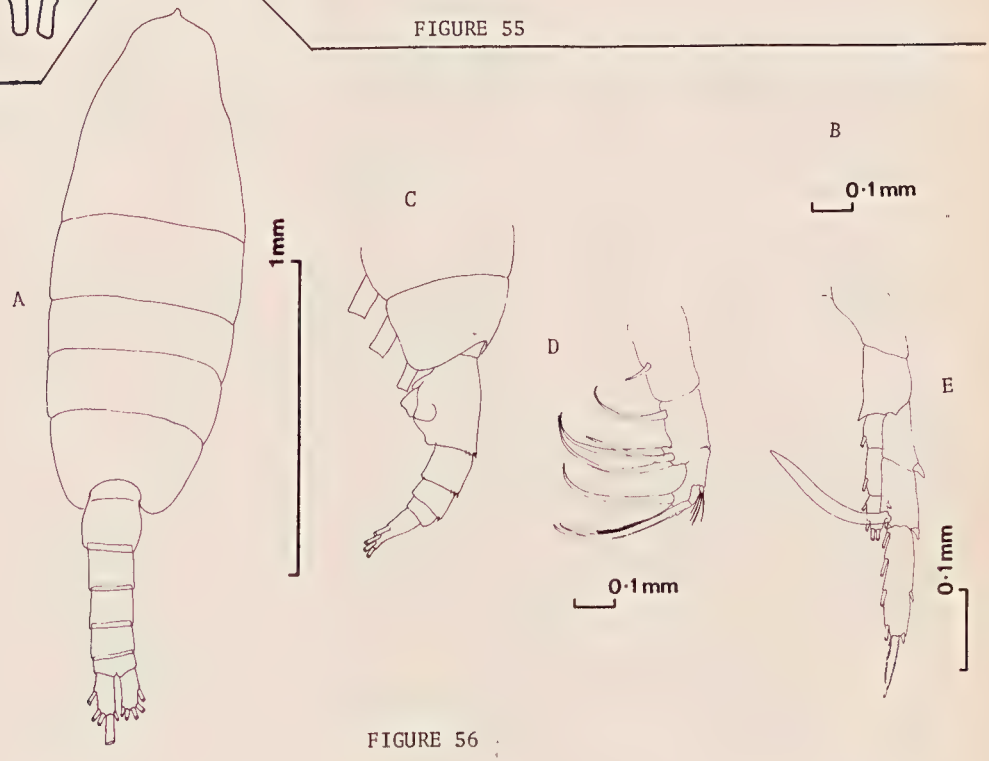


FIGURE 56

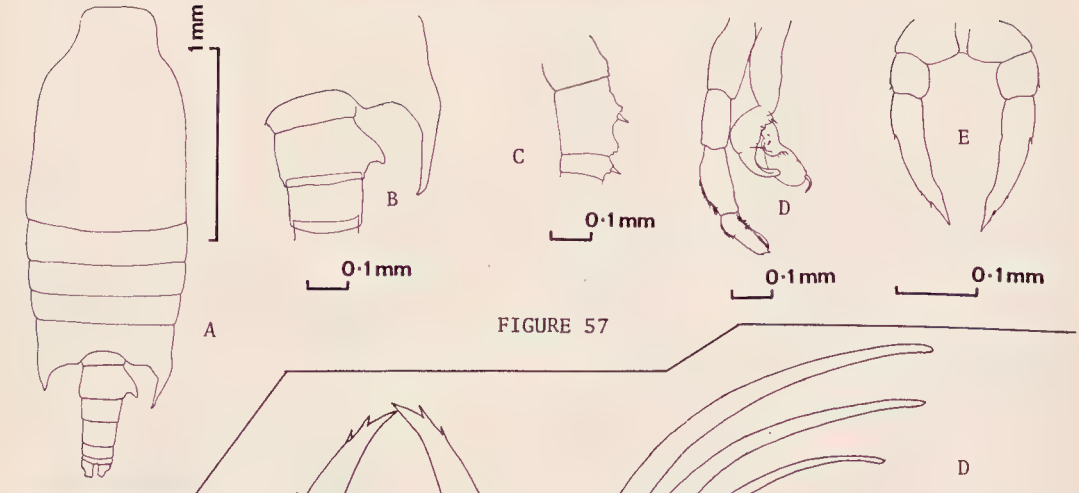


FIGURE 57

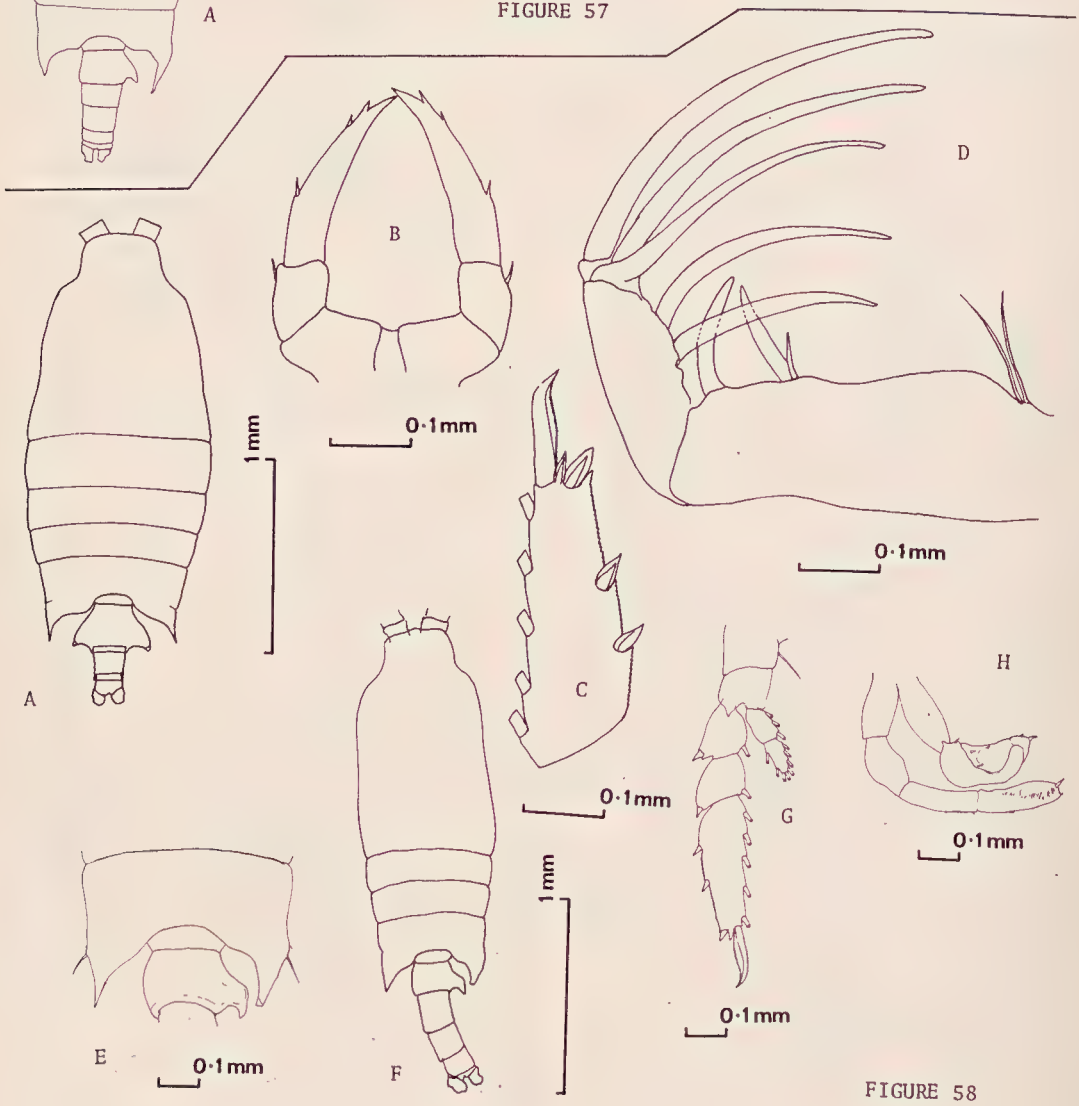


FIGURE 58

Occurrence: Station IC 3, September, 1971 - 1 female
Station E 11, November, 1972 - 1 male
Figure Explanations:
(a) male whole animal, dorsal view,
(b) posterior portion of metasome and anterior portion of urosome of male, dorsal view,
(c) proximal segments of male right first antenna,
(d) male fifth leg,
(e) female fifth leg.

Candacia bipinnata (Giesbrecht, 1888)
(figs 58a - h)

Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fifth leg,
(c) terminal exopodite segment of male third leg,
(d) female first maxilliped,
(e) male last metasomal segment and first urosomal segment, dorsal view,
(f) male whole animal, dorsal view,
(g) male third leg,
(h) male fifth leg.

Candacia tenuimana (Giesbrecht, 1888)
(figs 59a - d)

Previous Tasmanian Records: Nil.
Occurrence: Station E 1, November, 1972 - 1 male.
Figure Explanations:
(a) male whole animal, dorsal view,
(b) posterior portion of male metasome and first urosomal segment, dorsal view,
(c) male left fifth leg,
(d) male right fifth leg.

Paracandacia simplex (Giesbrecht)
(figs 60a - c)

Previous Tasmanian Records: Nil.
Occurrence: Station E 1, October, 1972 - 1 female.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fifth leg,
(c) female terminal exopodite segment of third leg.

Family PONTELLIDAE

Labidocera cervi Kramer, 1895
(figs 61a - g)

Previous Tasmanian Records: D'Entrecasteaux Channel (Ong, 1970).
Occurrence: Station IC 1, February, 1972 - 1 female. Off Roberts Point, D'Entrecasteaux Channel - 2 females, 3 males.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female last metasomal segment and urosome, lateral view,
(c) female mandible,
(d) female fifth leg,
(e) male last metasomal segment and urosome, dorsal view,
(f) male fifth leg,
(g) male terminal segments of right first antenna.

Labidocera tasmanica Nyan Taw, 1974
(figs 62a - g)

Previous Tasmanian Records: Storm Bay, Mouth of River Derwent and Northern parts of D'Entrecasteaux Channel (Nyan Taw 1974).
Occurrence: Inshore coastal and Coastal.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female last metasomal segment and urosome, lateral view,
(c) male whole animal, dorsal view,
(d) male whole animal, lateral view,
(e) female fifth leg, posterior aspect,
(f) male fifth leg, posterior aspect,
(g) proximal expansion of distal segment of male right fifth leg.

Family ACARTIIDAE

Acartia tranteri Bradford 1976
(figs 63a - d)

Reference Specimen: Tranter and Hammick, C.S.I.R.O., Cronulla, Bottle No. 12.
Previous Tasmanian Records: Derwent River Estuary (Ong 1967 as *A. clausi*).
Occurrence: Estuarine, Inshore coastal, Coastal and Oceanic.
Identified as *A. clausi*, by Ong. Present specimens resemble *A. tranteri* and this name will be retained pending specialist examination.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) male whole animal, dorsal view,
(c) female fifth leg,
(d) male fifth leg.

Acartia danae Giesbrecht 1889
(figs 64a - d)

Reference Specimen: Tranter and Hammick, C.S.I.R.O., Cronulla, Bottle No. 20.
Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fifth leg,
(c) female second leg,
(d) female fourth leg, posterior aspect.

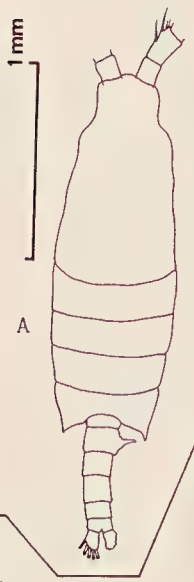
Sulcanus conflictus Nicholls, 1945
(figs 65a - d)

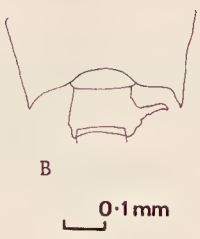
Previous Tasmanian Records: Derwent Estuary (Ong 1967, 1970).
Occurrence: Estuarine and Inshore coastal.
Figure Explanations:
(a) female whole animal, lateral view,
(b) female fourth leg,
(c) female fifth leg,
(d) male fifth leg.

Order CYCLOPOIDA

Family OITHONIDAE

Oithona atlantica (Farran, 1908)
(figs 66a - f)





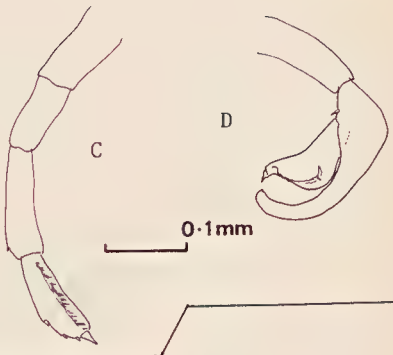


FIGURE 59

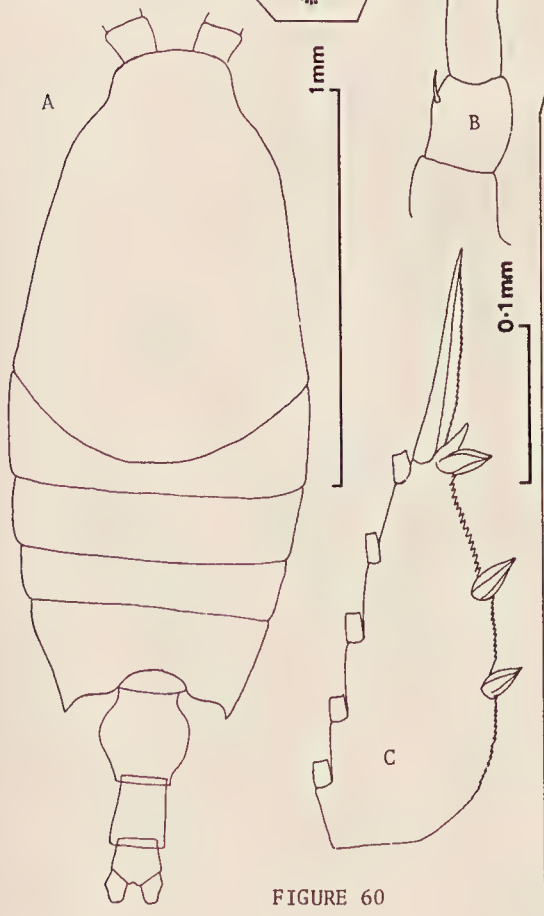
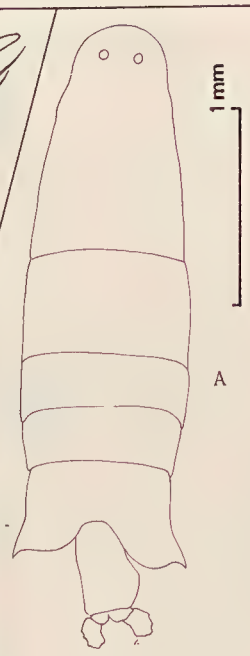
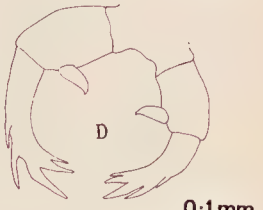
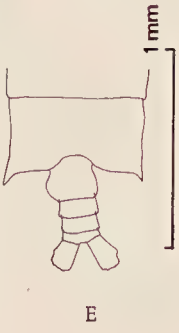


FIGURE 60







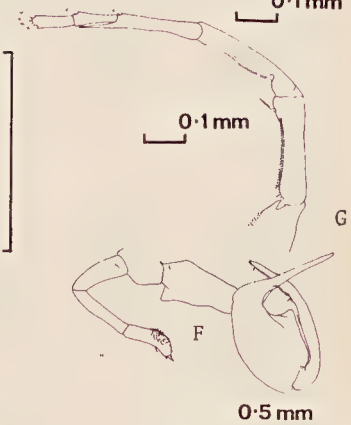


FIGURE 61

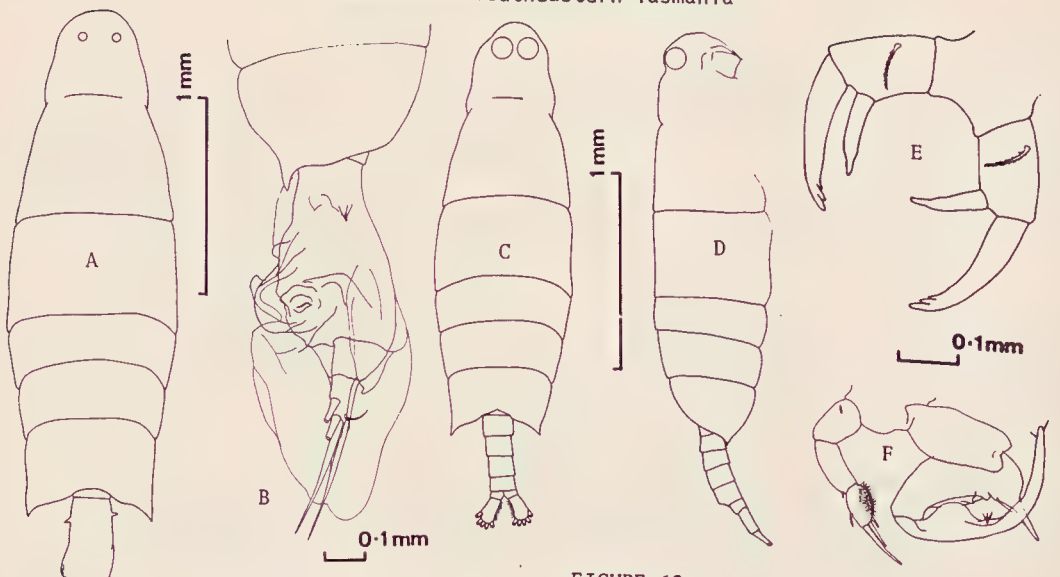


FIGURE 62

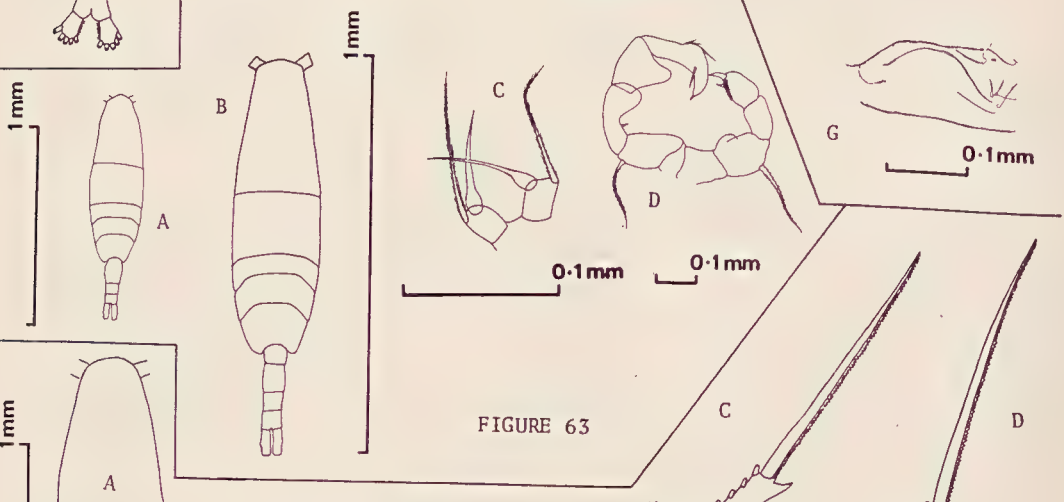


FIGURE 63

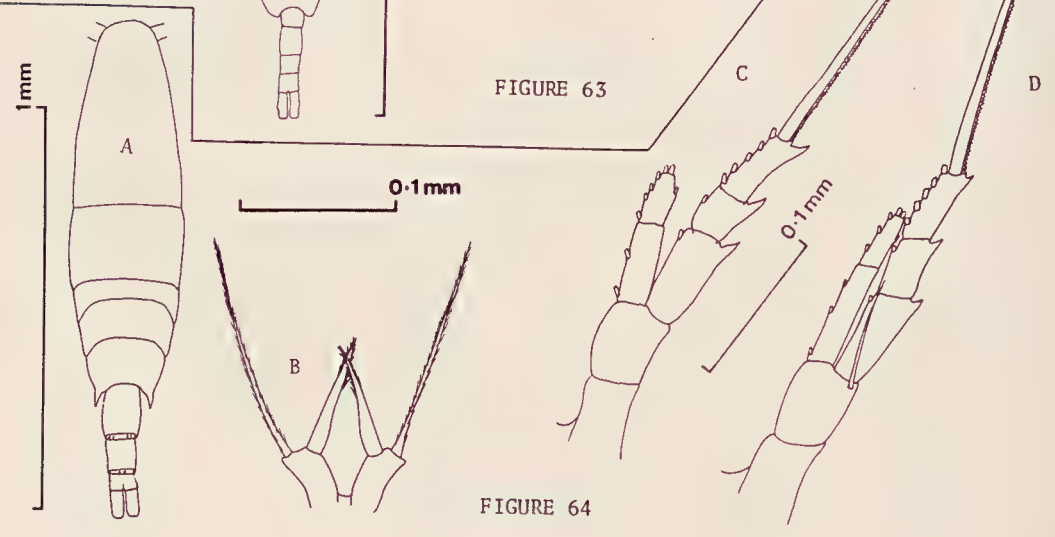


FIGURE 64

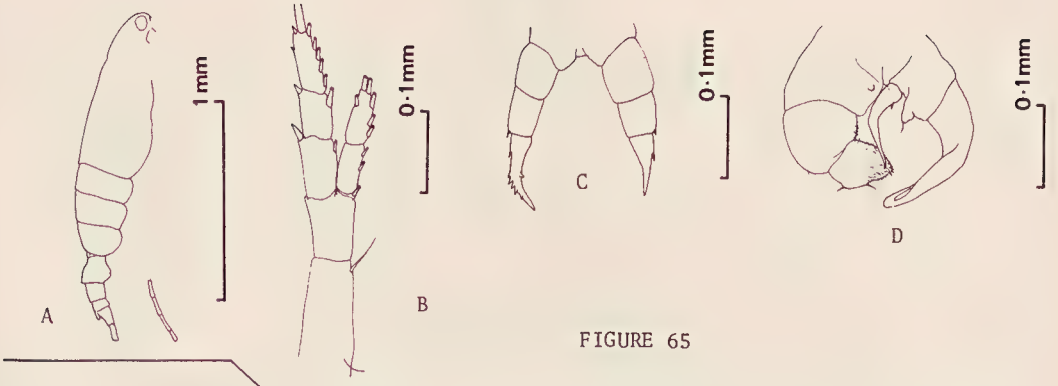


FIGURE 65

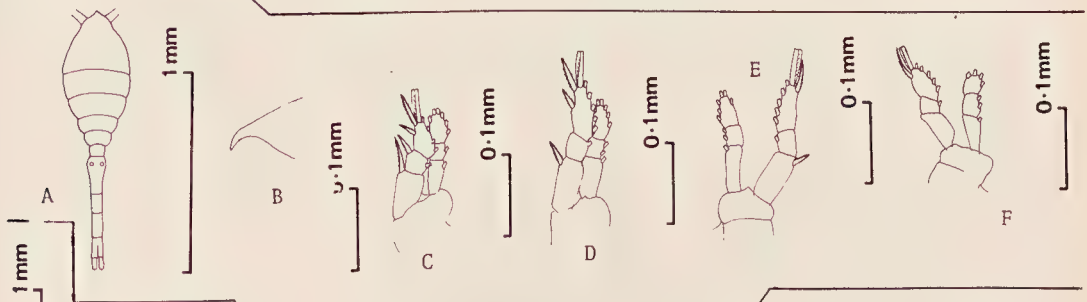


FIGURE 66

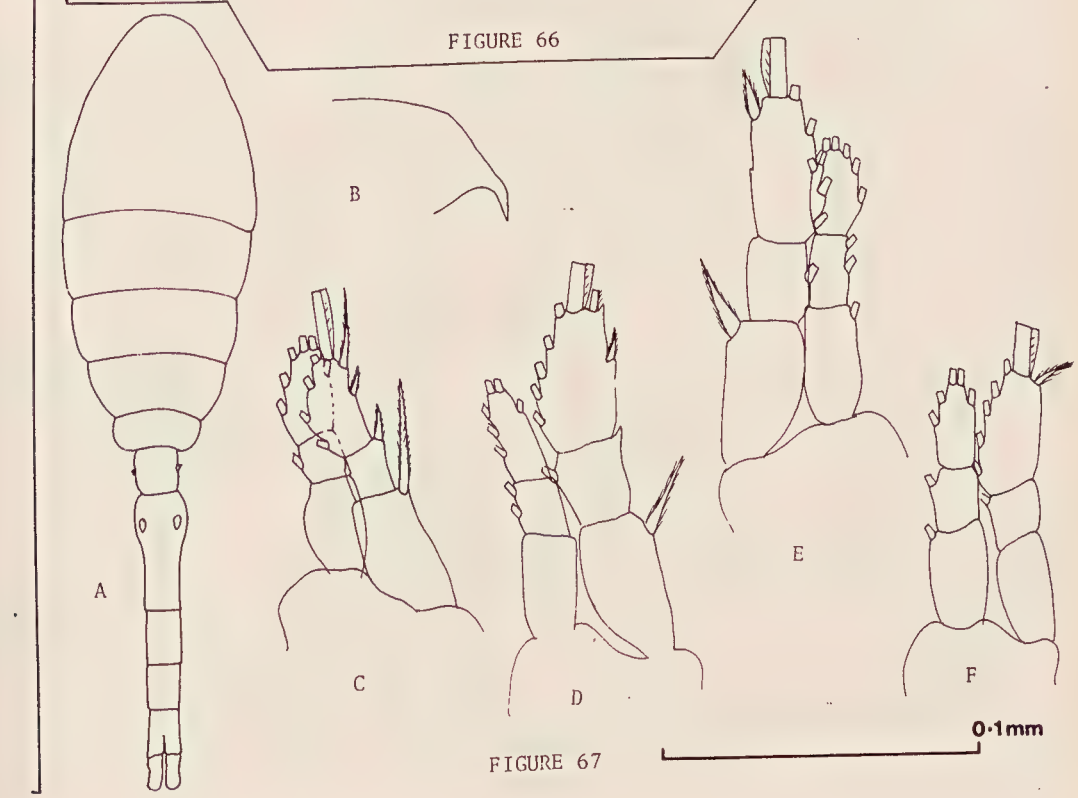


FIGURE 67

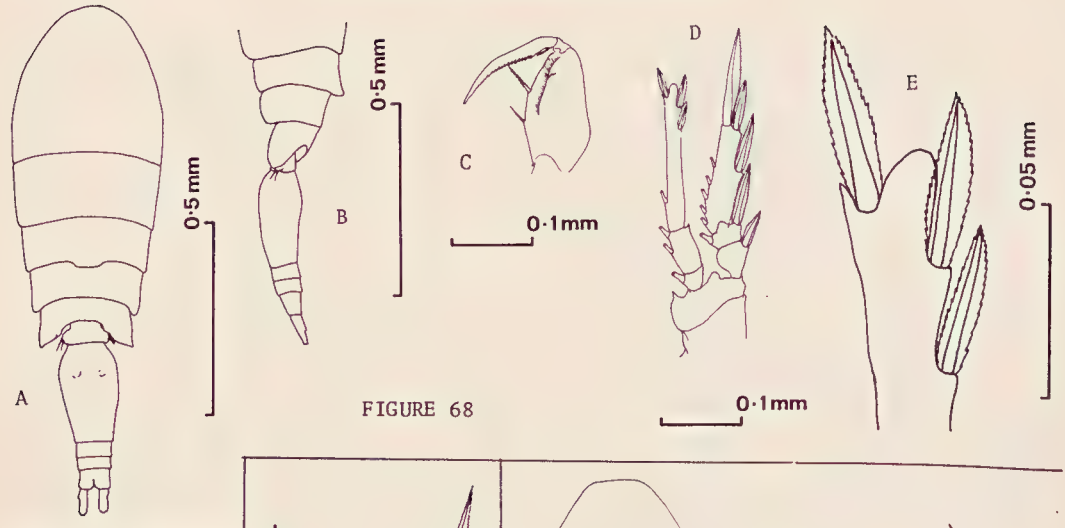


FIGURE 68

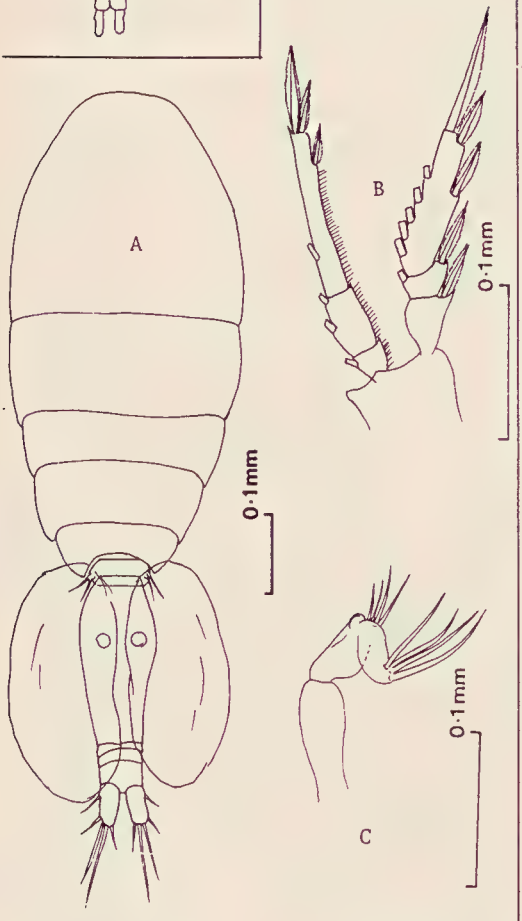


FIGURE 69

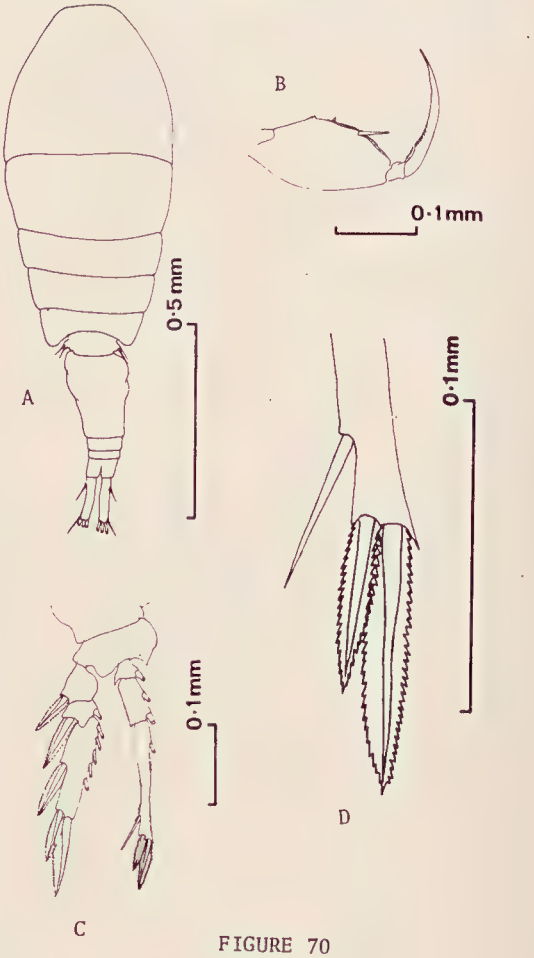


FIGURE 70

Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal (the occurrence of this species in the remaining areas was not determined due to the difficulties involved in identification.)
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female rostrum, lateral view,
(c) female first leg,
(d) female second leg,
(e) female third leg,
(f) female fourth leg.

Oithona tenuis Rosendorn, 1917
(figs 67a - f)

Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal (the occurrence of this species in the remaining areas was not determined due to the difficulties involved in identification).
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female rostrum,
(c) female first leg,
(d) female second leg,
(e) female third leg,
(f) female fourth leg.

Family ONCAEDIDAE

Oncaea conifera Giesbrecht, 1891
(figs 68a - e)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort 1972).
Occurrence: Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) posterior portion of female metasome and urosome, lateral view,
(c) female maxilliped,
(d) female fourth leg,
(e) terminal portion of distal endopodite segment of female fourth leg.

Oncaea media Giesbrecht, 1891
(figs 69a - c)

Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fourth leg,
(c) female second antenna.

Oncaea mediterranea (Claus, 1863)
(figs 70a - d)

Previous Tasmanian Records: South of Tasmania (44°05'S, 147°35'E) (Vervoort 1957).
Occurrence: Coastal and oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female maxilliped,
(c) female fourth leg,
(d) terminal portion of distal endopodite segment of female fourth leg.

Oncaea venusta (Phillippi, 1843)
(figs 71a - f)

Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) terminal portion of distal endopodite segment of female fourth leg,
(c) terminal portion of distal endopodite segment of female third leg,
(d) female maxilliped,
(e) male maxilliped,
(f) male urosome, dorsal view.

Order HARPACTICOIDA

Family TACHIDIIDAE

Euterpina acutifrons (Dana, 1852)
(figs 72a - f)

Previous Tasmanian Records: Nil.
Occurrence: Estuarine and Inshore coastal.
Figure Explanations:
(a) female whole animal, dorsal view,
(b) female fifth leg,
(c) male whole animal, lateral view,
(d) male first antennae,
(e) male second antennae,
(f) male fourth leg.

Sub-Class MALACOSTRACA

Order EUPHAUSIACEA

Euphausia lucens (Hansen, 1905)
(figs 73a - c)

Previous Tasmanian Records: Water around Tasmania (John 1936; Bradbury 1972).
Occurrence: Coastal and Oceanic.
Figure Explanations:
(a) adult female whole animal, lateral view,
(b) anterior part of carapace and antennal peduncles of adult female, lateral view,
(c) adult male copulatory organ.

Euphausia recurva Hansen, 1905
(figs 74a - c)

Previous Tasmanian Records: Northwest of Tasmania (Bradbury 1972).
Occurrence: Coastal and Oceanic.
Figure Explanations:
(a) adult female whole animal, lateral view,
(b) anterior part of carapace and antennal peduncles of adult female, lateral view,
(c) adult male copulatory organ.

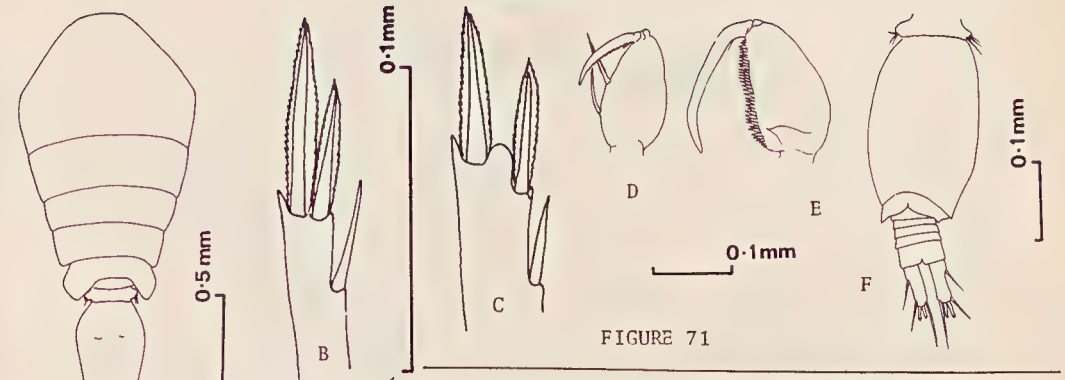


FIGURE 71

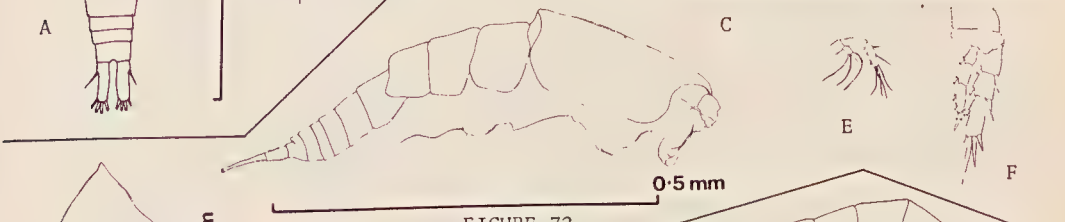


FIGURE 72

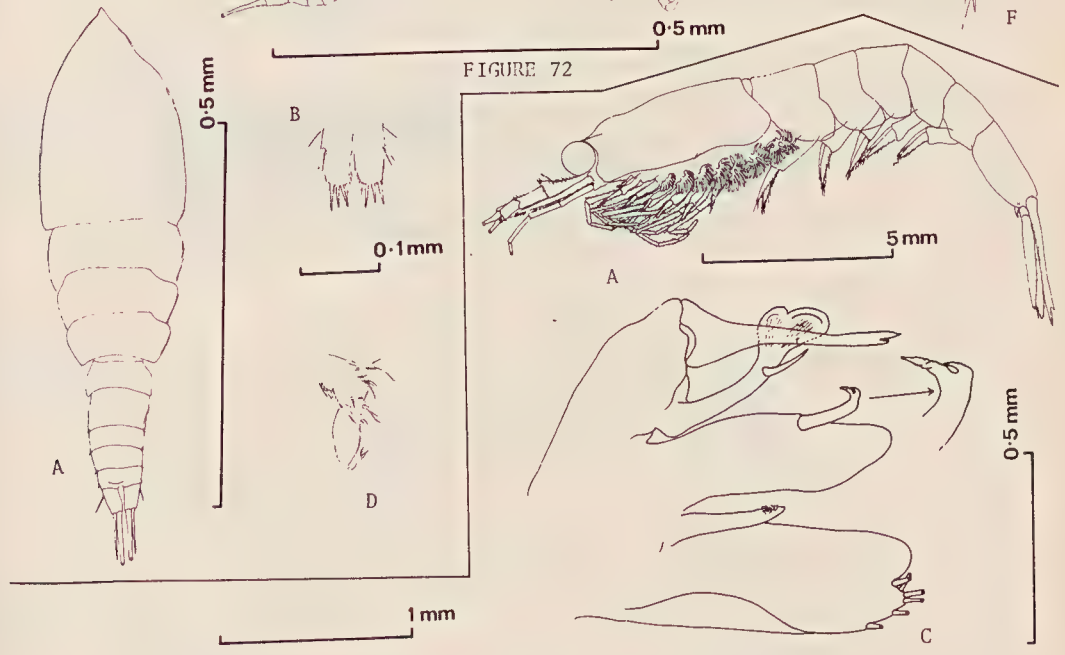


FIGURE 73

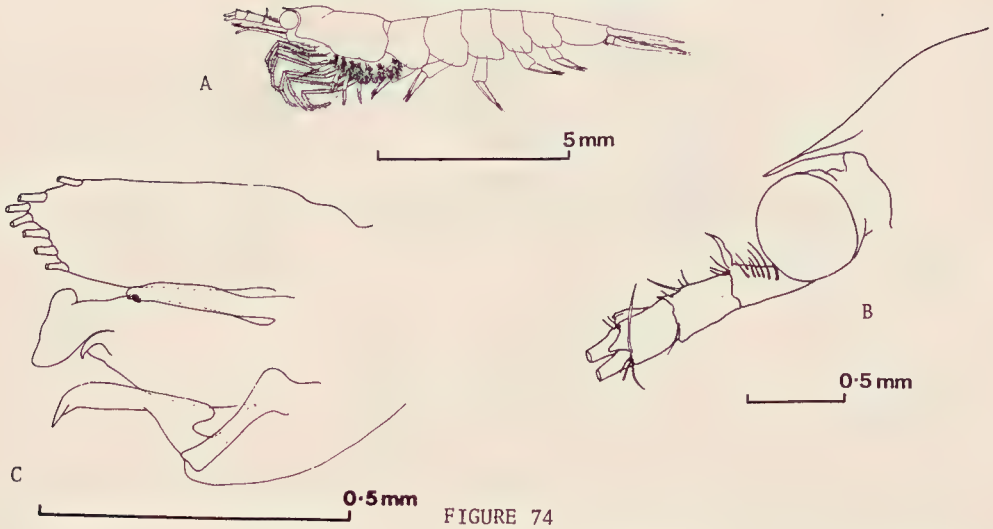


FIGURE 74

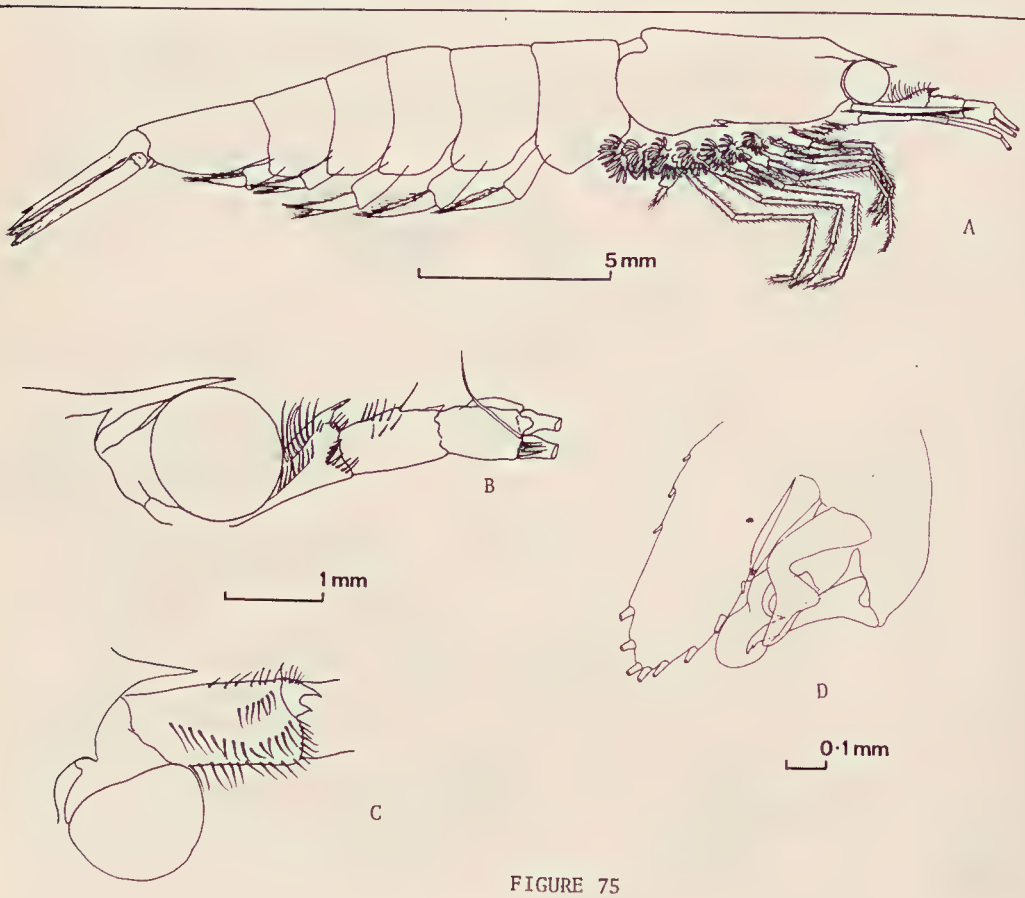


FIGURE 75

Euphausia similis (Sars, 1885)
(figs 75a - d)

Previous Tasmanian Records: South and eastern waters of Tasmania (John 1936; Bradbury 1972).
Occurrence: Station E 6, May, 1973 - 2 females, 2 males and 1 juvenile.
Figure Explanations:
(a) adult male whole animal, lateral view,
(b) anterior part of carapace and antennal peduncles of adult male, lateral
(c) and dorsal view,
(d) adult male copulatory organ.

Euphausia similis var. *armata* (Hansen, 1905)
(figs 76a - c)

Previous Tasmanian Records: Waters around Tasmania (John 1936; Bradbury 1972); Southwestern Tasmania (Sheard 1953).
Occurrence: Station E 6, November, 1971 - 8 females and 11 juveniles.
Station E 6, May, 1973 - 8 females, 2 males and 5 juveniles.
Figure Explanations:
(a) adult female whole animal, lateral view,
(b) adult male copulatory organ,
(c) female tooth on the mid-dorsal posterior margin of the third abdominal segment.

Euphausia longirostris (Hansen, 1905)
(figs 77a - c)

Previous Tasmanian Records: Southwest of Tasmania (Sheard 1953); South of Tasmania (Bradbury 1972).
Occurrence: Station E 6, May, 1973 - 1 adult female.
Figure Explanations:
(a) adult female whole animal, lateral view,
(b) anterior part of carapace and antennal peduncles of adult female,
(c) dorsal and lateral views.

Nyctiphanes australis Sars, 1885
(figs 78a - c)

Previous Tasmanian Records: Nil.
Occurrence: Inshore coastal and Coastal.
Figure Explanations:
(a) adult female whole animal, lateral view,
(b) adult male copulatory organ,
(c) anterior part of carapace and antennal peduncle of adult female, lateral view.

Nematoscelis megalops Sars, 1885
(figs 79a - d)

Previous Tasmanian Records: Water around Tasmania (Bradbury 1972).
Occurrence: Coastal and Oceanic.
Figure Explanations:
(a) adult female whole animal, lateral view,
(b) terminal segment of second thoracic leg,
(c) spine of the terminal segment of second thoracic leg,
(d) pre-anal spine.

Thysanoessa gregaria Sars, 1885
(figs 80a - e)

Previous Tasmanian Records: Nil.
Occurrence: Coastal and Oceanic.

Figure Explanations:
(a) adult female whole animal, lateral view,
(b) distal segments of female second thoracic leg,
(c) adult male copulatory organ,
(d) adult female pre-anal spine,
(e) adult male pre-anal spine.

Sub-Class EUCARIDA

Order DECAPODA

Family SERGESTIDAE

Lucifer hanseni (Nobili, 1905)
(figs 81a - e)

Previous Tasmanian Records: Derwent Estuary (Ong 1967).
Occurrence: Inshore coastal (the occurrence in the coastal and oceanic waters was not determined).
Figure Explanations:
(a) female whole animal, lateral view,
(b) male last abdominal segment and telson, lateral view,
(c) male telson, lateral view,
(d) male telson, dorsal view,
(e) male copulatory organ

Phylum CHAETOGNATHA

Eukrohnia hamata (Mobius, 1875)
(figs 82a - c)

Previous Tasmanian Records: Eastern coastal waters (Thomson 1947).
Occurrence: Station E 1, November, 1972 - 1 specimen.
Figure Explanations:
(a) whole animal, ventral view,
(b) detail structure of head, ventral view,
(c) detail structure of the eyes, dorsal view.

Pterosagitta draco (Krohn 1853)
(fig. 83)

Previous Tasmanian Records: Eastern Coastal waters (Thomson 1947).
Occurrence: Coastal and Oceanic.
Figure Explanation: whole animal, ventral view.

Sagitta gazellae (Ritter-Zahony, 1909)
(fig. 84)

Sagitta gazellae, David, 1955, pp. 244-254, figs. 1, 5a and b, 6b-e.
Previous Tasmanian Records: Eastern waters of Tasmania (David 1955; Thomson 1947 ?).
Occurrence: Coastal and Oceanic.
Figure Explanation: whole animal, ventral view.

Sagitta lyra (Krohn, 1853)
(fig. 85)

Previous Tasmanian Records: Nil.
Occurrence: Coastal and Oceanic.
Figure Explanation: whole animal, ventral view.

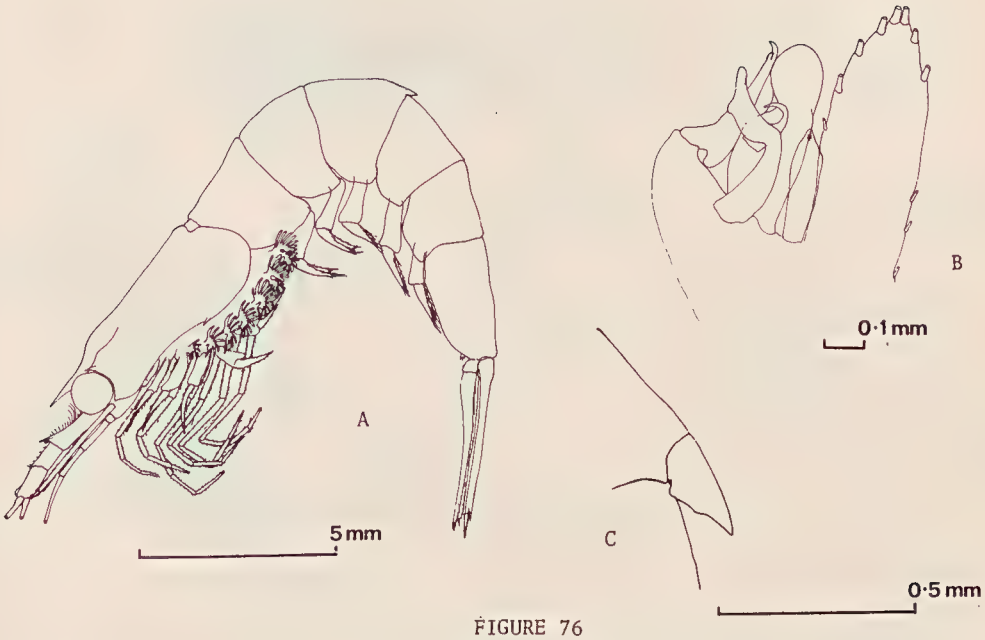


FIGURE 76

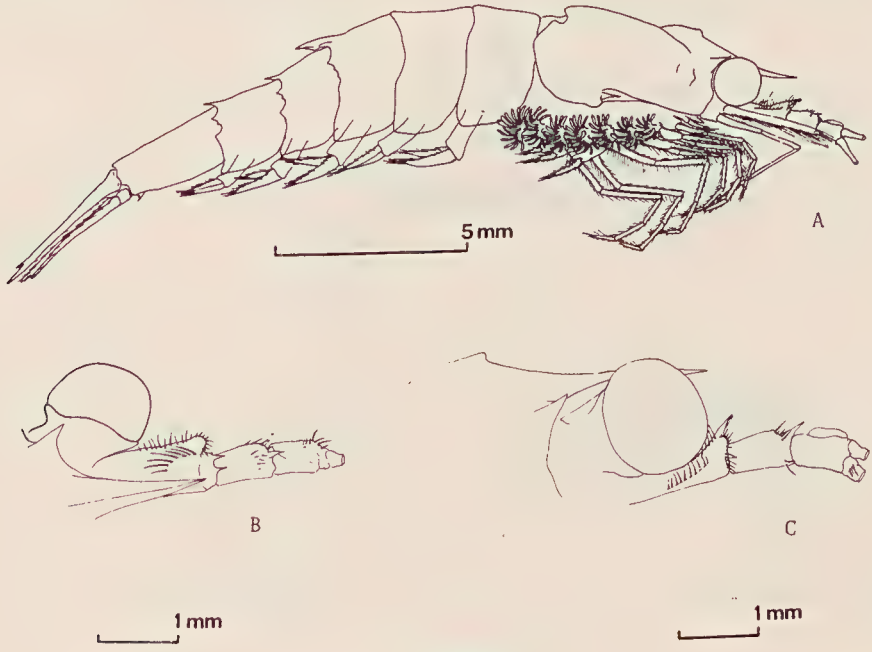


FIGURE 77

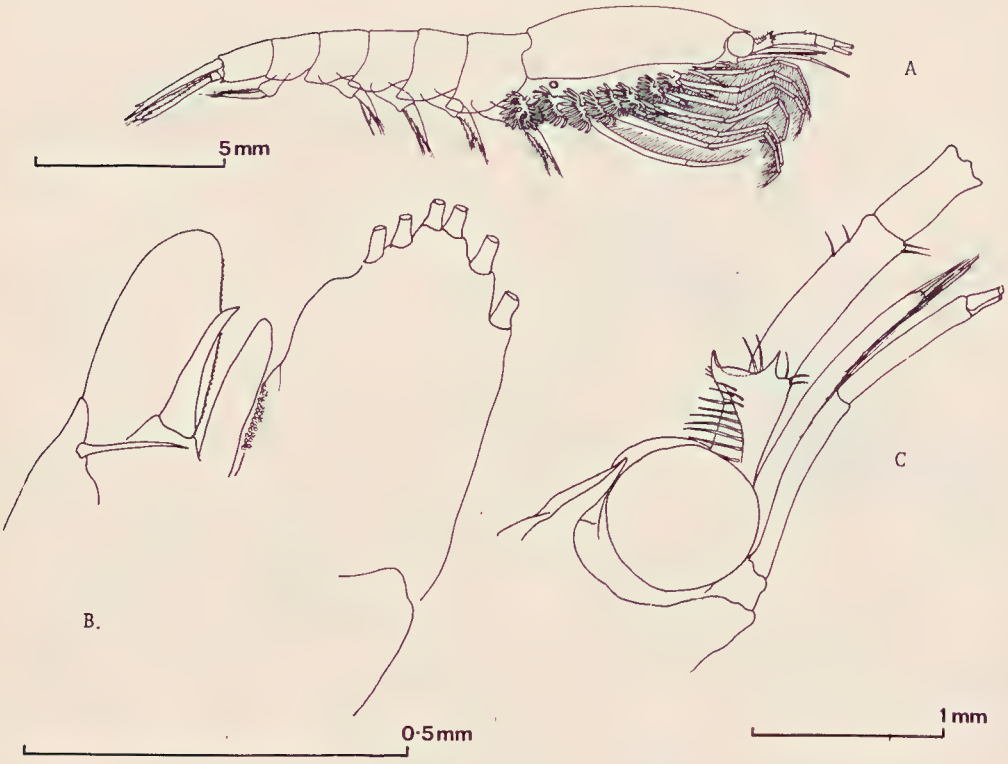


FIGURE 78

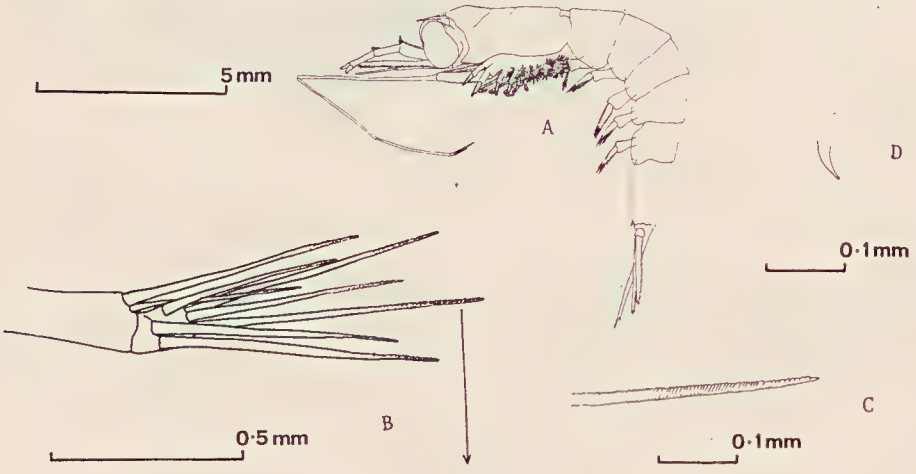


FIGURE 79

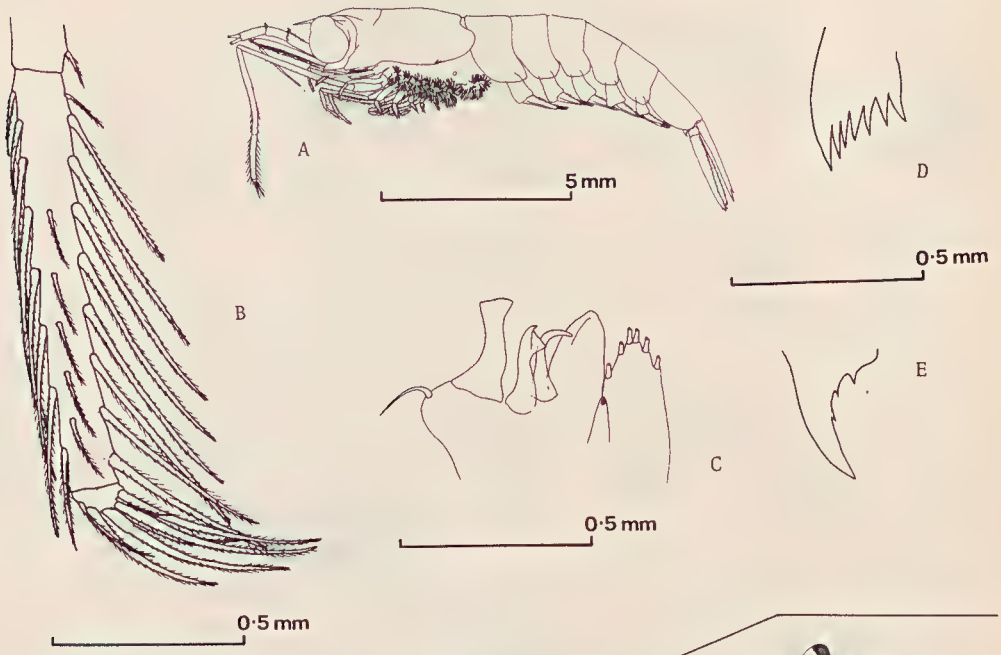


FIGURE 80

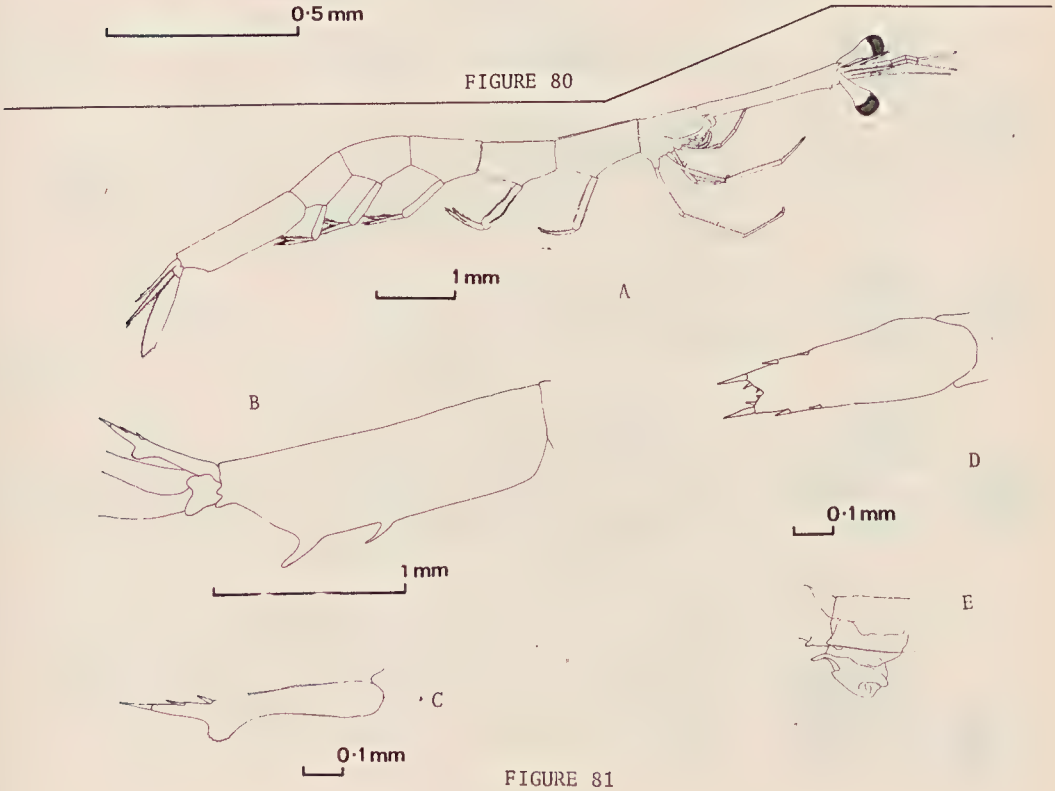


FIGURE 81

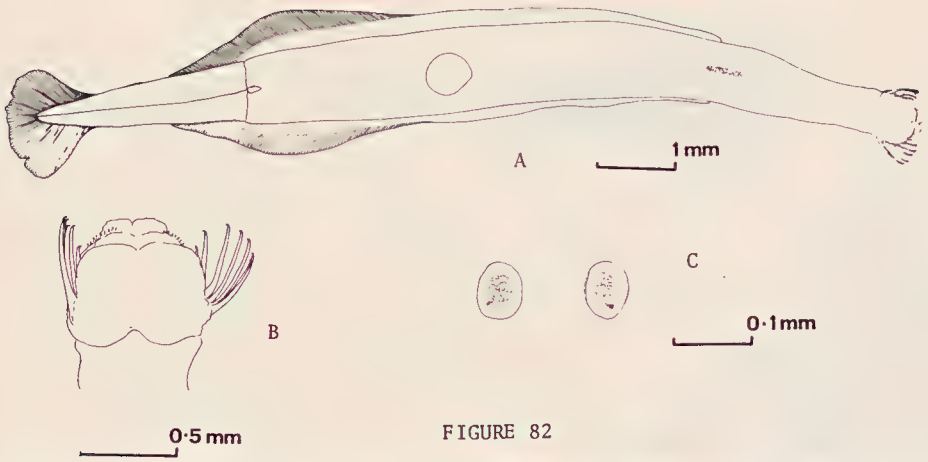


FIGURE 82

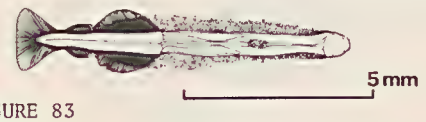


FIGURE 83

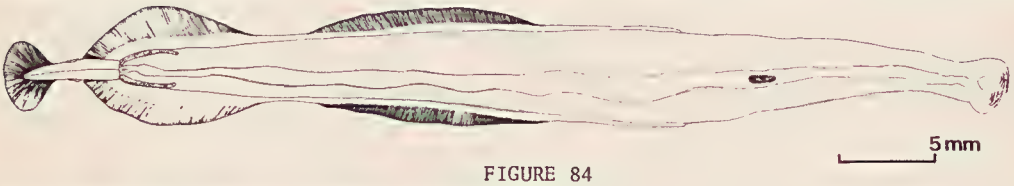


FIGURE 84

FIGURE 85

FIGURE 86

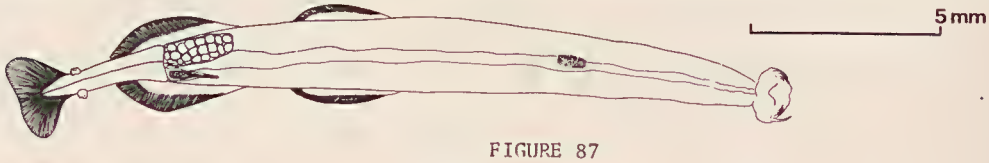


FIGURE 87

Sagitta hexaptera (D'Orbigny, 1853)
(fig. 86)

Previous Tasmanian Records: Eastern coastal waters (Thomson 1947).
Occurrence: Station E 11, August, 1971 - 3 specimens
Station E 1, March, 1972 - 1 specimen
Station E 7, April, 1972 - 1 specimen
Station E 10, May, 1973 - 1 specimen
Figure Explanation: whole animal, ventral view.

Sagitta enflata (Grassi, 1881)
(fig. 87)

Previous Tasmanian Records: Nil.
Occurrence: Station E 4, November, 1972 - 1 specimen.
Figure Explanation: whole animal, ventral view.

Sagitta serratodentata tasmanica Thomson, 1947
(figs 88a - b)

Previous Tasmanian Records: Eastern coastal waters (Thomson 1947).
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) whole animal, ventral view,
(b) seminal vesical.

Sagitta serratodentata atlantica Tokioka, 1940
(fig. 89)

Previous Tasmanian Records: Nil.
Occurrence: Station E 6, November, 1971.
Figure Explanation: seminal vesical.

Sagitta planctonis (Steinhaus, 1896)
(fig. 90)

Previous Tasmanian Records: Eastern Coastal waters (Thomson 1947; David 1956).
Occurrence: Coastal and Oceanic.
Figure Explanation: whole animal, ventral view.

Sagitta minima (Grassi, 1881)
(fig. 91)

Previous Tasmanian Records: Eastern coastal waters (Thomson 1947).
Occurrence: Estuarine, Inshore coastal, Coastal and Oceanic.
Figure Explanation: whole animal, ventral view.

Sagitta guileri Nyan Taw, 1975
(figs 92a - g)

Previous Tasmanian Records: Nyan Taw (1975a).
Occurrence: Estuarine and Inshore coastal.
Figure Explanations:
(a) whole animal, ventral view,
(b) ventral view of anterior region of the head, showing anterior and posterior teeth,
(c) detail structure of eye,
(d) detail structure of third right (counted from ventral side) hook,
(e) detail structure of distal region of third right hook,
(f) mature seminal vesicle,
(g) mature seminal vesicle (bursting).

Phylum TUNICATA

Class ACOPA or CADUCICHORDATA

Order PYROSOMIDA

Pyrosoma atlanticum atlanticum (Peron, 1804)
Previous Tasmanian Records: Eastern coastal waters (Thomson 1948).
Occurrence: Inshore coastal, Coastal and Oceanic.

Order CYCLOMYARIA

Only oozooid stages (e.g. fig. 93) were taken in the present study.

Order DESMOMYARIA

Thetys vagina (Tilesius, 1802)
(fig. 94)
Previous Tasmanian Records: Waters around Tasmania (Thompson 1948, 1954).
Occurrence: Station E 5, June, 1972 - 5 Aggregate forms
Station E 7, June, 1972 - 12 Aggregate forms
Station E 9, June, 1972 - 3 Aggregate forms
Figure Explanation: aggregate form.

Iasis zonaria (Pallas, 1774)
(figs 95a - b)
Previous Tasmanian Records: Waters around Tasmania (Thompson 1948, 1954).
Occurrence: Station E 3, November, 1971 - 8 Aggregate forms
Station E 4, December, 1971 - 7 Aggregate forms
Station E 1, March, 1972 - 1 solitary form, 4 Aggregate forms.
Figure Explanations:
(a) solitary form, dorsal view,
(b) aggregate form, dorsal view.

Thalia democratica (Forskal, 1775)
(figs 96a - b)
Previous Tasmanian Records: Eastern coastal waters (Thompson 1948).
Occurrence: Station E 10, October, 1972 - 2 Aggregate forms
Station E 7, November, 1972 - 2 Aggregate forms, 1 solitary form
Station E 9, November, 1972 - 3 Aggregate forms
Figure Explanations:
(a) solitary form, dorsal view,
(b) aggregate form, dorsal view.

Salpa fusiformis Cuvier, 1804
(figs 97a - b)
Previous Tasmanian Records: Waters around Tasmania (Thompson 1948, 1954).
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanations:
(a) aggregate form, ventral view,
(b) solitary form, dorsal view.

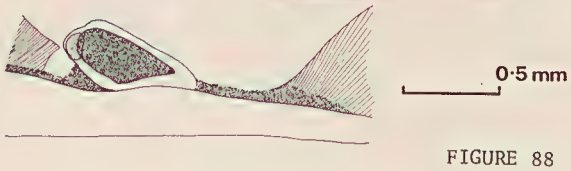


FIGURE 88

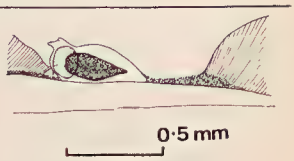


FIGURE 89

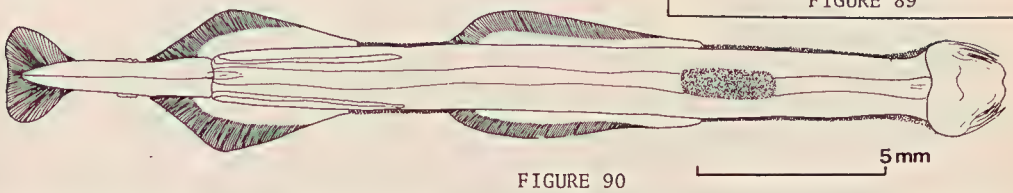


FIGURE 90

FIGURE 91

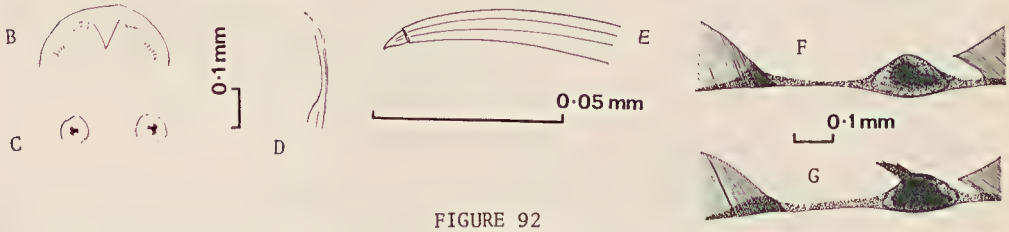


FIGURE 92

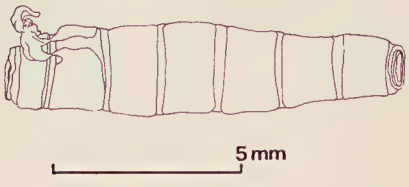


FIGURE 93

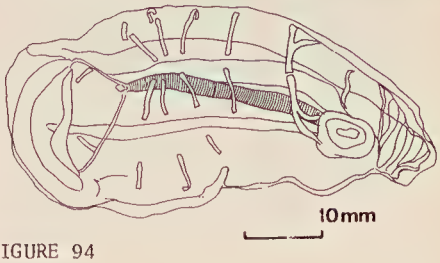


FIGURE 94

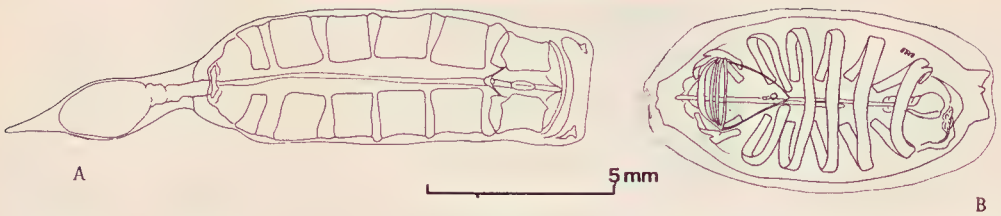


FIGURE 95

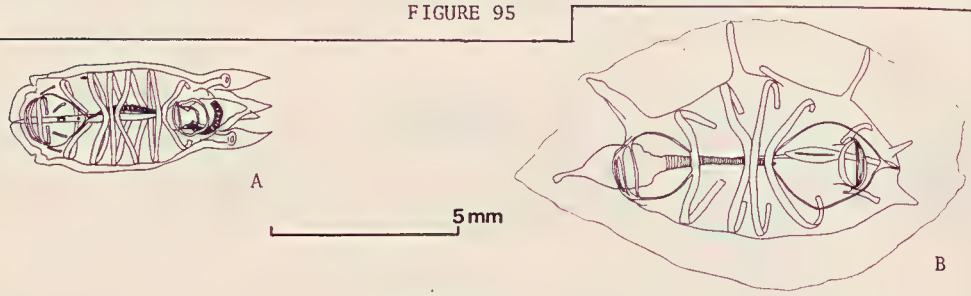


FIGURE 96

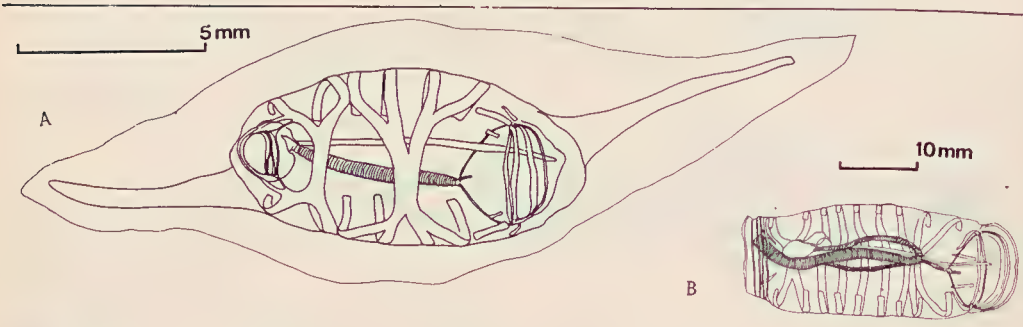


FIGURE 97

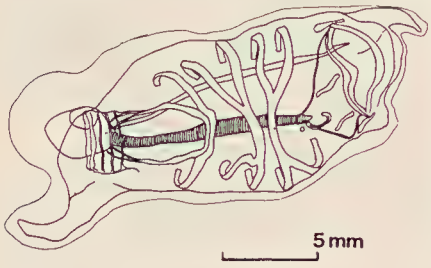


FIGURE 98

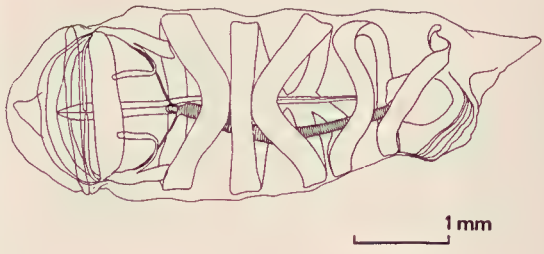


FIGURE 99

Salpa maxima (Forskal, 1775)
(fig. 98)
Previous Tasmanian Records: Eastern coastal waters (Thompson 1948).
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanation: aggregate form, dorsal view.

Ihlea magalhanica (Apstein, 1894)
(fig. 99)
Previous Tasmanian Records: Eastern coastal waters (Thompson 1948).
Occurrence: Inshore coastal, Coastal and Oceanic.
Figure Explanation: aggregate form, dorsal view.

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LATE CAMBRIAN FOSSILS FROM THE CLIMIE FORMATION, WESTERN TASMANIA

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(with one table, one text figure and three plates)

ABSTRACT

The Climie Formation, which is about 460 metres thick in the type section of the Dundas Group, contains the youngest known fossils within the Dundas Group. Just south of the Murchison Highway bridge over the Dundas Rivulet the Climie Formation is overturned, sheared and contains poorly preserved fossils in two main horizons, which are well exposed in road cuttings.

The lower fauna occurs about 200 metres below the top of the formation, while the upper fauna occurs about 145 metres below the top of the formation. The lower fauna contains the inarticulate brachiopods *Angulotreta*(?) sp., and *Lingulella*(?) sp., plus the trilobites described herein as *Olenus* sp., *Neoagnostus* sp., *Agnostus* sp., and Ceratopygidae, gen et sp. indet. Five fragmentary trilobite specimens are left in open nomenclature. The upper fauna contains the inarticulate brachiopods described herein as *Lingulella*(?) sp., and Acrotretidae, incertae sedis plus the trilobites *Agnostus* sp., *Lotagnostus*(?) sp., *Peltura*(?) sp., and an unassigned member of the Olenidae. It is suggested that the lower fauna is probably of early post-Idamean age, with the higher fauna being slightly younger. Both faunas are of a cosmopolitan nature and indicate easy communication with the open ocean at the time of deposition.

INTRODUCTION

The purpose of this paper is to describe the Late Cambrian faunas of the Climie Formation, near Dundas in Western Tasmania. Elliston (1954) first mapped the Cambrian sediments of this area and defined the Dundas Group to include thirteen formations with a total thickness of 11,575 feet. This succession was amended slightly by Banks (1956, 1962). Blissett (1962) extensively revised the concept of the Dundas Group, rejected some of Elliston's formations and completely remapped the Dundas area. As noted by Jago (1971) the term Dundas Group should be confined to the section between Razorback and Misery Hills. A. Brown of the Geological Survey of Tasmania is currently investigating the geology of the Dundas area.

The top part of the Dundas Group as detailed by Elliston (1954) and Blissett (1962) is shown in Table 1. As shown in Table 1, Elliston considered that the Misery Conglomerate was part of the Dundas Group and that it was in possible fault contact with the Gordon Limestone of the Junee Group. However, Blissett considered that the Misery Conglomerate was equivalent to the Mt. Zeehan Conglomerate and other basal conglomerates of the Junee Group in Western Tasmania, with the Climie Formation being the top member of the Dundas Group. Blissett considered that the contact between the Climie Formation and the Misery Conglomerate was conformable, a view supported by Williams (1975). Jago (1974) suggested that the contact could be a paraconformity.

Whatever the relationship between the Climie Formation and the Misery Conglomerate, the faunas described below are of considerable significance because they are by far the highest known faunas in the Dundas Group. The top of the Brewery Junction Formation contains a late Mindyallan fauna of *Glyptagnostus stolidotus* Zone age (Jago 1972). Only one fossil, a very poorly preserved olenid trilobite cranidium, is known from the

TABLE 1

COMPARISON OF THE UPPER PART OF DUNDAS GROUP AS DETAILED BY ELLISTON (1954) AND BLISSETT (1962)

(a) Elliston (1954)	Th. (m)	(b) Blissett (1962)	Th. (m)
Ordovician			
JUNEE GROUP		JUNEE GROUP	
Gordon Limestone		Misery Conglomerate	
?Faulted contact?			
Cambrian			
DUNDAS GROUP		DUNDAS GROUP	
Misery Conglomerate	150		
Climie Slate and Tuff	610	Climie Formation	460
Fernflow Conglomerate and Tuff	145	Fernflow Formation	150
Comet Slate and Tuff	320	Comet Formation	150-300
Fernfields Tuff and Conglomerate	595	Fernfields Formation	?0-595
Brewery Junction Slate and Tuff	745	Brewery Junction Formation	610

Th. = Thickness

Fernfields Formation. The Comet Formation contains a few very poorly preserved brachiopod fragments. The Fernflow Formation has yet to yield any fossils.

The Climie Formation is about 460 metres thick in the type section along Dundas Rivulet. As noted by by Blissett (1962, p.31), this sequence is "composed mainly of purple and green greywacke, siltstone and highly cleaved shale." Williams (1975) described the upper part of the Climie Formation in the vicinity of the quarry on the north flank of Misery Hill.

In the vicinity of the Murchison Highway bridge over the Dundas Rivulet, the Climie Formation is overturned and sheared. A short distance south of this bridge the Climie Formation is well exposed in road cuttings, where fossils were discovered in January 1969 by the writer and Dr. B. Daily at lat. 41°54.2'S, long 145°24.2'E. The fossils are generally poorly preserved due to the highly sheared nature of the sediments, and some are seen only as "ghosts" (e.g. pl.3, fig.14), although other fossils are moderately well preserved.

There are two horizons (fig.1) at which fossils are found in reasonable abundance. The lower fauna occurs about 200 metres below the top of the formation, while the upper fauna occurs about 145 metres below the top of the formation. The lower fauna contains the inarticulate brachiopods *Angulotreta*(?) sp. (common), and *Lingulella*(?) sp. (rare), plus the trilobites described below as *Olenus* sp. (common), *Neoagnostus* sp. (common), *Agnostus* sp. (moderately common), rare examples of Ceratopygidae, gen. et sp. indet, Trilobita sp.1, Trilobita sp.2, Trilobita sp.3, Trilobita sp.4 and Trilobita sp.5. The fossils of the upper fauna are much less abundant that those of the lower fauna. The upper fauna contains the brachiopods described below as *Lingulella*(?) sp., and Acrotretidae, incertae sedis, and the trilobites *Agnostus* sp., *Lotagnostus*(?) sp., *Peltura*(?) sp., and Olenidae gen. et sp. indet. Of these, all are rare except *Agnostus* sp., which is moderately abundant.

The composition of neither fauna is distinctive enough to give an accurate age. The earliest representatives of *Neoagnostus* listed by Shergold (1977) are post-Idamean but pre-Payntonian. The presence of *Olenus* sp. suggests that the lower fauna is no younger than the Australian equivalent of the Scandinavian *Olenus* Zone. In Queensland, *Olenus* ranges at least as high as the *Irvingella tropica* Zone, the top zone of the

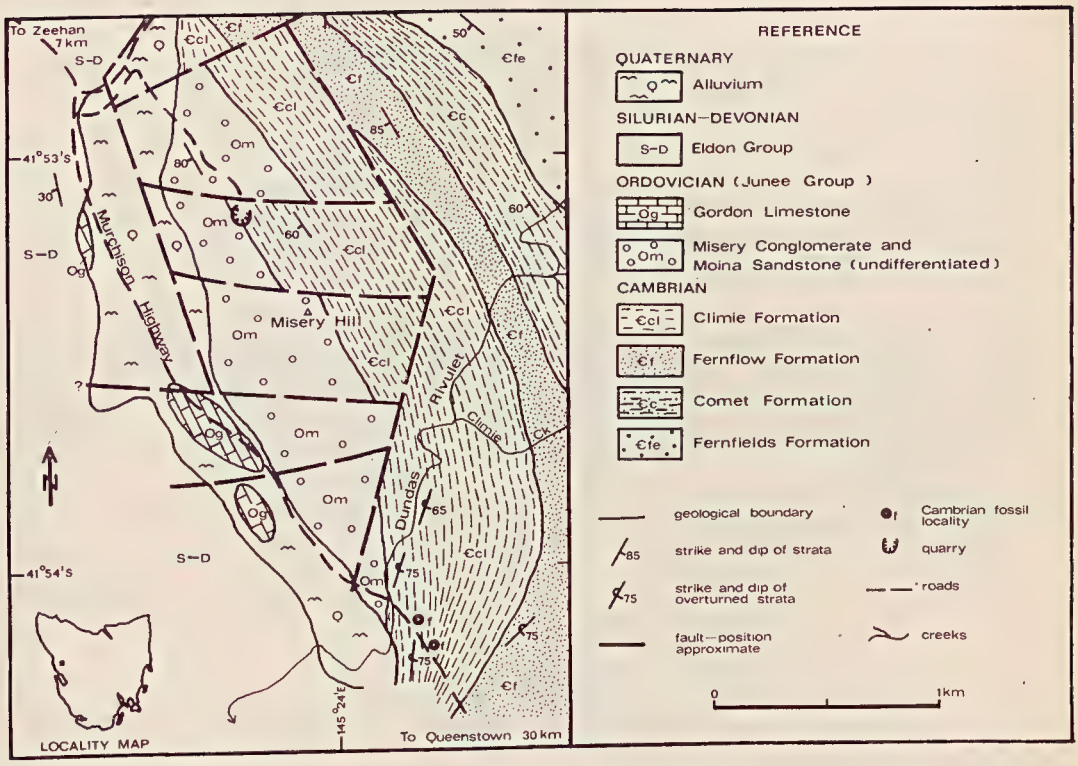

FIG. 1 - Geology of the Misery Hill area (modified after Blissett, 1962).

Idamean (Henderson 1976, p.357). However, as noted by Henderson, correlations between the Australian upper Idamean and the Scandinavian sequences are uncertain.

The presence of a possible *Peltura* and a possible *Lotagnostus* in the upper fauna of the Climie Formation suggests an age somewhat later in the Late Cambrian than those mentioned above. In Scandinavia, *Peltura* does not occur until Zone 5c, which correlates approximately with the pre-Payntonian B "stage" of Queensland (Jones *et al.* 1971). This is consistent with the known age range of *Lotagnostus*.

However, *Peltura*(?) sp. and *Lotagnostus*(?) sp. are known only from single specimens. Hence, it seems better to place more weight on the specimens of the lower fauna for the purposes of age determination. The combination of *Neoagnostus* and *Olenus* suggests a late Idamean or early post-Idamean age, with the later being favoured. Assuming that there was no major depositional break between the time of deposition of the lower and upper faunas, then the upper fauna is presumably slightly younger than the lower fauna.

Williams (1975) noted that the uppermost part of the Climie Formation was of shallow water origin. The faunas noted above are of a cosmopolitan nature indicating

easy communication to the open ocean, and are probably Late Cambrian equivalents to Assemblages 1 and 2 of Jago (1973). However, this does not necessarily imply deep water deposition.

All Tasmanian Cambrian fossils have undergone tectonic distortion to some extent. As noted by Henningsmoen (1960, p.207), there are three main types of symmetrical distortion with respect to the orientation of bilaterally symmetrical fossils such as trilobites and brachiopods: (a) a dorso-ventral compression (flattening), (b) sagittal elongation (the L form of Henningsmoen) (e.g. pl. 1, fig. 18), and (c) transverse elongation (the W form) (e.g. pl. 1, fig. 12). Those fossils in which the distortion has been asymmetrical are stated here to have undergone intermediate distortion, (i.e. the compression took place at an oblique angle to the length of the trilobite, e.g. pl. 2, fig. 3). In cases where no comment is made about the type of distortion, it is because the type of distortion is difficult to determine.

All statements made in the descriptions, such as the cephalon is about as wide as is long, are made after taking the effect of distortion into account. Admittedly, this is a subjective assessment, but I feel that, after inspecting and studying several thousand distorted trilobite and brachiopod specimens, such a judgment seems reasonable. Unless otherwise stated, all length measurements of trilobites were taken in a sagittal or exsagittal line, all width measurements were taken in a transverse direction.

All specimens are housed in the collection of the Geology Department, University of Tasmania. The catalogue numbers refer to this collection.

SYSTEMATIC DESCRIPTIONS

Phylum BRACHIOPODA Dumeril, 1806
Class INARTICULATA Huxley, 1869
Order LINGULIDA Waagen, 1885
Superfamily LINGULACEA Menke, 1828
Family OBOLIDAE King, 1846
Genus *LINGULELLA* Salter, 1866

Type species: *Lingula davisi* M'Coy, 1851, p.405

Lingulella(?) sp.
(Pl. 1, figs. 1-3)

Material: Two decorticated specimens of a large inarticulate brachiopod are known from the Climie Formation.
Description: One specimen (UT 96712a, pl.1, fig.3) is a brachial valve from the lower fauna. It is 8.0 mm long and about 6.0 mm wide. It has an elongate-ovate outline. There are closely spaced fine growth lines (microlines of Biernat and Tomczykowa, 1968) plus at least three concentric macrolines, which are most prominent in the anterior part of the shell. There is a faint radial ribbing. The second specimen (UT 96713, pl.1, figs. 2 & 3) is a pedicle valve from the upper fauna; it is about 11.0 mm long and about 9.0 mm wide. It has a slightly more pointed umbo than has the brachial valve. Due to poor preservation it is difficult to determine if the narrow elongate structure at the posterior end of the valve is genuine or simply an artifact caused by the distortion of the shell. There are fine concentric growth lines on this specimen, but no macrolines. Altered chloritic remnants of the shell material in UT 96713 (pl.1, fig. 3) indicate that it was thin shelled. Even allowing for the flattening and distortion of the two specimens, it would appear that the valves were only gently convex.
Discussion: Although the two specimens come from different horizons, they seem to belong to the same genus, and are tentatively placed in *Lingulella*.

Occurrence: Climie Formation, upper and lower faunas.

Order ACROTRETIDAE Kuhn 1949
Suborder ACROTRETIDINA Kuhn 1949
Superfamily ACROTRETACEA Schuchert 1893
Family ACROTRETIDAE Schuchert 1893

Genus *ANGULOTRETA* Palmer 1955

Type Species: *Angulotreta triangularis* Palmer 1955, p. 769, pl. 91, figs. 1-6.

Angulotreta(?) sp.
(pl. 1, Figs. 4-10)

Material: About twenty individual pedicle and brachial valves are available. One very poorly preserved specimen has the valves still joined together.
Description: The pedicle valve has a high proconical profile (pl. 1, fig. 6). The apparent difference in the position of the beak in UT 96714b (pl. 1, fig. 4) as compared with UT 96715a (pl. 1, fig. 7) is due to the slightly different angle at which the specimens were photographed. No details of the valve interior are visible. The brachial valve is gently convex. A short median septum is visible on one specimen (UT 96716a, pl. 1, fig. 10). No other details of the shell interior are visible. Faint concentric growth lines are visible on both valves.
Discussion: The state of preservation is such that no definite generic assignation can be made. However, the overall shape and appearance of the available specimens suggests affiliation with *Angulotreta*, to which genus they are tentatively referred.
Occurrence: Climie Formation, lower fauna.

ACROTREDIDAE Incertae sedis

One poorly preserved acrotretid, which has both valves present, is known from the upper fauna (pl. 1, fig. 11).

Class TRILOBITA Walch, 1771
Order MIOMERA Jaekel, 1909
Suborder AGNOSTINA Salter, 1864
Superfamily AGNOSTACEA M'Coy, 1849
Family AGNOSTIDAE M'Coy, 1849
Subfamily AGNOSTINAE M'Coy, 1849

Genus *AGNOSTUS* Brogniart, 1822

Type species: *Entomostracites pisiformis* Wahlenberg, 1821.

Agnostus sp.
(pl. 1, figs. 12-23)

Material: There are four reasonably complete specimens, plus several individual cephala and pygidia available for description.
Description: Moderately convex cephalon about as wide as is long. Narrow border with shallow, narrow marginal furrow and a narrow convex rim. The posterolateral corners are nowhere well preserved. Smooth cheeks are separated at the anterior by a shallow preglabellar median furrow which extends to the marginal furrow.

Glabella is outlined by narrow, moderately deep axial furrows, which shallow slightly to the anterior. Glabella is slightly more convex than the cheeks; it has a length about 0.7 that of cephalon. Broadly rounded glabellar rear; small, simple

basal lobes.

The narrow, shallow, transverse glabellar furrow is arched posteriorly. Anterior glabellar lobe has a subpentagonal outline; it has a length about 0.35-0.4 that of the glabella. Immediately to the posterior of the transverse glabellar furrow, the glabella widens slightly, and immediately behind this slight expansion, there is a slight constriction of the glabella. The posterior glabellar lobe has a faint node at its centre.

The moderately convex pygidium is about as wide as is long. The border is slightly wider than that of the cephalon with a shallow marginal furrow and a narrow, slightly elevated, almost flat rim at the posterior which becomes more convex to the anterior. Short border spines; narrow, shallow shoulder furrows; the shoulders are narrow, convex and elevated. The fulcra appear to be close to the axis. Neither the facets nor the articulating device are preserved. The pleural areas are smooth; there is no postaxial median furrow.

The moderately wide trilobate axis is outlined by moderately deep, narrow furrows. The axis has a length about 0.7-0.75 that of the pygidium. The first two axial lobes have a combined length about 0.4-0.45 that of the axis; they are separated by narrow, shallow lateral furrows which are directed quite strongly inwards and forwards. The second axial lobe is separated from the posterior lobe by an almost straight transverse furrow which is bent back at its centre around the posterior of an elongated, convex ridge which extends the length of the anterior pair of axial lobes. This ridge separates the anterior laterial furrows. The posterior axial lobe is slightly expanded; the axial rear is evenly rounded; the axis is constricted at the second axial lobe.
Discussion: This species belongs in *Agnostus* Brongniart, 1822. However, it is not well enough preserved to be referred to either an existing species or be the basis of a new species.
Occurrence: Climie Formation, upper and lower faunas.

Genus *LOTAGNOSTUS* Whitehouse, 1936

Type Species: *Agnostus trisectus* Salter, 1864, p.10, pl. 1, fig. 11

Lotagnostus(?) sp.
(pl. 2, fig. 1)

Only one large cephalon, UT 92571, is known from the upper fauna. It is a poorly preserved internal mould (length, 4.7 mm, width, 7.3 mm). There is a narrow, shallow marginal furrow and a flat, moderately wide rim. The little of the acrolobe that is preserved shows strong scrobiculation.

This cephalon could possibly belong in *Lotagnostus* Whitehouse, *Xestagnostus* Öpik, or *Agnostus* Brongniart. It is placed questionably in *Lotagnostus* until more specimens are known.

Family DIPLAGNOSTIDAE Whitehouse 1936 emend. Öpik 1967
Subfamily PSEUDAGNOSTINAE Whitehouse 1936

Genus *NEOAGNOSTUS* Kobayashi 1955

Type Species: *Neoagnostus aspidoides* Kobayashi 1955, p. 473, pl. 7, fig. 5 (holotype cephalon), *non* pl. 7, fig. 4 (pygidium).

Diagnosis: See Shergold 1977, p. 93.
Discussion: Shergold (1977) has comprehensively discussed *Pseudagnostus* and the

related genera *Neoagnostus* and *Rhaptagnostus*. He has divided *Neoagnostus* into four species groups; Shergold's concept and terminology are followed here.

Neoagnostus sp.
(pl. 2, figs. 2-15)

Material: A total of about forty individual cephala and pygidia are available. Two very poorly preserved complete specimens are available.
Description: Moderately convex, spectaculate cephalon is about as wide as is long. The acrolobes are unconstricted. Narrow rim; moderately wide marginal furrow. Short preglabellar median furrow appears to be present in some specimens (e.g. UT 96724b; pl.2, fig. 7), but not in others (e.g. UT 96720b; pl.2, fig. 3). It may be significant that the specimens, in which the furrows appear to be present are mostly internal moulds, whereas those in which the furrow is absent are external moulds. Small basal lobes do not meet behind the glabellar rear. Distinct axial furrows shallow forwards. Length of glabella about two-thirds that of cephalon. Glabella is widest at anterolateral lobes, where it is about one-third the width of the cephalon. The shallow transverse glabellar furrow is arched gently to the posterior. Large anterolateral lobes are separated from the posterior part of the glabella by shallow furrows which curve inwards and forwards. Slightly elongated glabellar node is placed at anterior end of posterior lobe and between the posterior parts of the anterolateral lobes.

The gently convex pygidium may be slightly longer than is wide. It has unconstricted acrolobes. The pygidial borders are slightly wider than the cephalic borders. Marginal furrows narrow anteriorly. Short, thick spines placed opposite end of deuterolobe. Anterior part of axis is well defined by axial furrow; the axis narrows posteriorly to the rear of the more posterior of two faintly outlined axial lobes. The shallow furrow at the posterior of the second axial lobe is deflected posteriorly at its centre by the prominent elongated node which runs almost the full length of the anterior pair of axial lobes. Accessory furrows are well defined anteriorly but fade posteriorly, although, in most specimens their faint outline can be traced to the posterior border. The accessory furrows meet the posterior border on the adaxial side of the marginal furrows. The intranotular axis is faintly outlined in most specimens, particularly at the posterior end where there is a well defined posterior node.

Discussion: The rather distinctive cephalon of the Climie Formation specimens indicates affiliation with *Neoagnostus*. It may be a new species distinguished by clearly outlined accessory furrows, a well defined intranotular axis and a prominent posterior node. However, the preservation of the Climie Formation specimens is such that the erection of a new species is undesirable.

Shergold (1977) places four species groups within *Neoagnostus*. However, the poor preservation makes determination of the group into which the Climie Formation species falls rather difficult.
Occurrence: Climie Formation, lower fauna.

Superfamily OLENACEA Burmeister 1843
Family OLENIDAE Burmeister 1843
Subfamily OLENINAE Burmeister 1843

Genus *OLENUS* Dalman 1827

Type Species: *Entomostracites gibbosus* Wahlenberg 1821
Diagnosis: See Henningsmoen 1957, p.96.

Olenus sp.
(pl. 3, figs. 3, 5-15)

Material: Several almost complete specimens are available. However, these are all poorly preserved and in some cases are simply "ghosts" (e.g. pl. 3, fig. 14). The description of the cranidium is based largely on the well preserved specimen, UT 92678 (pl. 3, fig. 5). Several other cranidia in various states of preservation are available.

Description

Cranidium: The glabella is quite convex and stands out well above the rest of the rather flat cephalon. Length of glabella (including occipital ring) is about two-thirds that of cranidium. From the posterior the glabella expands very slightly up to the level of the 1p furrows; anterior of the 1p furros it tapers gently forwards. It has a bluntly rounded front, which may have a small centrally placed indentation. Occipital ring is short (sag.), elevated and gently convex, with a small central node. Well developed occipital furrow. Three pairs of glabellar furrows. The most posterior pair (1p) are deep, slightly sigmoidal, and directed strongly backwards; they are deepest at their centre. The second pair (2p) of furrows are shallower, straighter and not as strongly backward directed as the 1p furrows. The anterior pair of furrows (3p) are quite close to the glabellar front and are situated close to the points where the ocular ridges meet the glabella. They are more a pair of depressions than distinct furrows.

The palpebral areas of the fixed cheeks have a width about half that of the glabella. The straight postocular facial sutures diverge greatly. The preocular facial sutures are gently curved. Well developed, narrow palpebral lobes are situated opposite the centroanterior part of the glabella. Narrow, well-developed ocular ridges run inwards and slightly forwards from the anterior part of the palpebral lobes. Very wide preglabellar field has a length (sag.) about one-third that of the cranidium. Faint genal caecae present in preglabellar field of the best preserved specimen (UT 92678; pl. 3, fig. 5). Narrow anterior border, widest at its midpoint; narrow, shallow marginal furrow. Almost straight, wide posterior marginal furrows widen abaxially. Posterior border of moderate width.

Librigenae: Librigenae are attached to two poorly preserved cranidia (UT 96742 and UT 9674b; pl. 3, figs. 7 and 10 respectively). They are transversely narrow, with narrow lateral borders which continue on to long genal spines. Narrow lateral border furrows are continuous with the posterior border furrows.

Thorax: At least 13 thoracic segments are present on the very poorly preserved almost complete specimen UT 96744b (pl. 3, fig. 10), although the exact number is difficult to determine because of the poor preservation. There is a well developed axial region, the pleural furrows are well developed and there are short spines at the end of each thoracic segment.

Pygidium: Well-developed axial region of four or five rings, well rounded posterior stops just short of the posterior border. Axis has a width about 0.3 that of pygidium. Two or three pairs of ribs on pleural areas; at least two of these ribs extend into short spines.

Discussion:

The overall appearance of this species indicates affiliation with *Olenus*. However, it differs from all known species of *Olenus* in the possession of a very long preglabellar area, e.g. none of the several species of *Olenus* discussed and described by Henningsmoen (1957) has a preglabellar area anywhere near as large as the Climie Formation species. With respect to the size of the preglabellar field, the Climie Formation species is probably closest to *Hunanolenus* Liu. However, the species of *Hunanolenus* described and figured by Liu (1977) have twenty-three thoracic segments, whereas the Climie Formation species has about thirteen or fourteen segments, as have some species of *Olenus*. Thus, I prefer to place the Climie Formation specimens in *Olenus*. They almost certainly belong in a new species of *Olenus*, but until better material is found

it is inadvisable to formally erect a new species.
Occurrence: Climie Formation, lower fauna.

OLENINAE, gen et sp. indet
(pl. 3, fig. 4)

Material: One very poorly preserved cephalon and two anterior thoracic segments (UT 96740).
Remarks: This specimen, from the upper fauna of the Climie Formation, may belong in *Olenus*. However, the preglabellar field of this specimen seems to be shorter (sag.) than *Olenus* sp. from the lower fauna.

Subfamily PELTURINAE Hawle and Corda, 1847

Genus *PELTURA* Milne Edwards, 1840

Type Species: *Entomostracites scarabaeoides* Wahlenburg 1821
Diagnosis: See Henningsmoen 1957, p.231.

Peltura(?) sp.
(pl. 3, fig. 2)

Material: One very poorly preserved almost complete specimen, UT 96739. The preservation is such that a formal description is unwarranted.
Remarks: The form of the glabella and of the fixed cheeks of this specimen are similar to that of *Peltura*. However, until better preserved specimens are found, this species will be only tentatively referred to that genus.
Occurrence: Climie Formation, upper fauna.

Superfamily CERATOPYGACEA Linnarsson 1869
Family CERATOPYGIDAE Linnarsson 1869

Genus et sp. indet
(pl. 2, figs. 16, 20)

Material: Two internal moulds of incomplete pygidia (UT 96732 and UT 96733) from the lower fauna are available.
Description: The pygidium has a very wide border which exhibits faint terrace lines. The axis of the more complete specimen has six axial rings. The axis stops just short of the border and has a length about 0.7 that of the pygidium. The anterior pleurae are well developed, although only the base of the spines which emerge from these pleurae are present in the available specimens. There are three other pairs of ribs on the pleural areas.
Discussion: The well developed anterior pleurae and attached spine bases indicate that both specimens belong in the Ceratopygidae. However, there is insufficient material to make a definite generic or specific assignment.

TRILOBITA INCERTAE SEDIS

Specimen 1
(pl. 2, fig. 2)

Material: One poorly preserved incomplete cranidium UT 96737.
Description: The little of the specimen that is visible shows a well developed occipital furrow. The moderately deep 1p glabellar furrows are strongly backwards directed and almost meet at the glabellar axis. The well developed 2p furrows do not extend as far into glabellar centre as do the 1p furrows. The 3p furrows appear as short,

shallow and directed slightly forwards. Palpebral areas of fixed cheeks are small. Prominent, wide palpebral lobes extend from opposite the occipital furrow to about opposite the 3p glabellar furrows.

Discussion: The well developed occipital furrow, the prominent palpebral lobes, small palpebral areas of the fixed cheeks and forwards directed 3p glabellar furrows all suggest affiliation of this specimen with *Stigmatoa*. However, until further, and better preserved material is found then this specimen must remain in open nomenclature.

Occurrence: Climie Formation, lower fauna.

Specimen 2
(pl. 2, fig. 17)

Material: One large partial cranidium, UT 96734, in which only the anterior part of the glabella and the preglabellar area are preserved.
Description: The only pair of glabellar furrows visible are wide shallow depressions placed well to the posterior of the bluntly rounded glabellar front. A small part of a low ocular ridge is preserved. The preglabellar area is long, wide, and has a narrow raised rim. The furrows outlining the glabellar are quite prominent.

Discussion: This specimen may belong in *Briscoia* or a related genus, but more material is required before an accurate identification can be made. This specimen may be part of the same species as the specimens described under Specimen 3.

Occurrence: Climie Formation, lower fauna.

Specimen 3
(pl. 2, fig. 18)

Material: Two large, poorly preserved pygidia, the better preserved of which (UT 96735) is figured.

Description: Large pygidium with axis which stops well short of posterior border. Pygidial margins are entire and non-spinose. Pygidial axes consists of six rings. There are four pairs of pleural ribs which extend almost right across the very wide border area.

Discussion: See Specimen 2 discussion.

Occurrence: Climie Formation, lower fauna.

Specimen 4
(pl. 2, fig. 19)

Material: A few spinose free cheeks are present in the lower fauna. The best preserved of these (UT 96736b) is figured.

Description: These free cheeks are characterized by a long, thin genal spine, a posterior border of moderate width, a shallow posterior marginal furrow and a moderately wide lateral border. Genal caecae are present on the genal field.

Discussion: It is possible that either of the free cheeks described here as specimens 4 and 5 were associated in life with specimens 2 and 3.

Occurrence: Climie Formation, lower fauna.

Specimen 5
(pl. 3, fig. 1)

Remarks: One large free cheek, UT 96738, is present. It apparently has no well developed border, lateral or posterior marginal furrows, or a genal spine.
Occurrence: Climie Formation, lower fauna.

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PLATE 1

Figs. 1-3. *Lingulella*(?) sp.

1. UT 96712b, brachial valve, rubber cast of external mould, L form,X5.5.
2. UT 96712a, internal mould of specimen figured in fig. 1, X5.
3. UT 96713, pedicle valve, W form,X2.7.

Figs. 4-10. *Angulotreta*(?) sp.

4. UT 96714b, pedicle valve, L form, X5.3.
5. UT 96714b, brachial valve, W form, X7. 6 and 7, UT 96715a, internal mould of pedicle valve exterior.
6. profile, X6.5.
7. X4.6.
8. UT 96715b, rubber cast of pedicle valve exterior, same specimen as figured in figs. 6 and 7, X6.
9. UT 96712b, rubber cast of poorly preserved brachial valve, W form, X9.3.
10. UT 96716a, brachial valve showing poorly preserved median septum, W form,X6.5.

Fig. 11. Acrotretidae, Incertae sedis, UT 96717, X10.

Figs. 12-23. *Agnostus* sp.

12. UT 92535, nearly complete specimen, W form, X7.8.
13. UT 92540, partial pygidium, X10.
14. UT 96714b, partial pygidium, L form, X19.
15. UT 92541, cephalon, L form, X10.
16. UT 92537, pygidium, L form, X10.8.
17. UT 92536, almost complete specimen, L form, X5.8.
18. UT 92536, internal mould of specimen figured in fig. 17, X5.5.
19. UT 96718b, nearly complete specimen, L form, X8.5.
20. UT 92539, poorly preserved partially complete specimen, W form,X5.
21. UT 96714b, cephalon, L form, X8.5.
22. UT 96711, pygidium, W form, X8.
23. UT 96712b, internal mould of pygidium, W form, X8.

Unless otherwise stated, all figures of trilobites are of rubber casts of external moulds. All specimens were whitened with magnesium oxide prior to photography. The specimens illustrated in figures 3, 11, 12, 15, 16, 17, 18 and 20 come from the upper fauna of the Climie Formation. All other specimens come from the lower fauna.

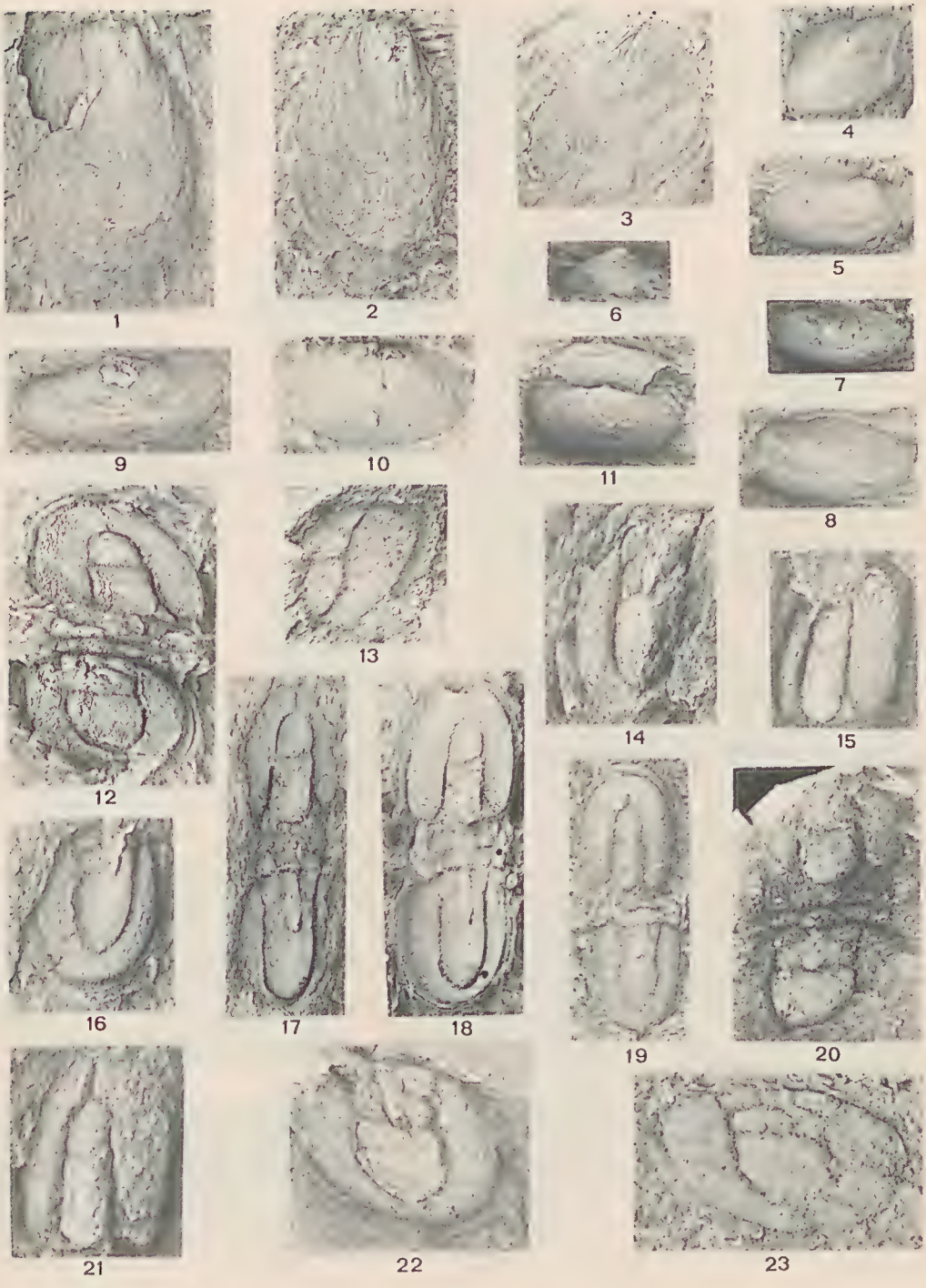

PLATE 1

PLATE 2

Fig. 1. *Lotagnostus*(?) sp., UT 92571, internal mould of a poorly preserved cephalon, W form, X4.7.

Figs. 2-15. *Neoagnostus* sp.
2. UT 96719, poorly preserved, small complete specimen, L form, X8.
3. UT 96720b, cephalon, intermediate distortion, X10.
4. UT 96721a, cephalon, intermediate distortion, X9.
5. UT 96722, internal mould of pygidium, intermediate distortion, X10.5.
6. UT 96723a, pygidium, W form, X11.
7. UT 96724b, internal mould of cephalon, intermediate distortion, X8.6.
8. UT 96725a, pygidium, L form, X8.
9. UT 96726, cephalon, W form, X10.
10. UT 96727, pygidium, L form, X7.8.
11. UT 96728, pygidium, intermediate distortion, X8.5.
12. UT 96729, pygidium, W form, X6.5.
13. UT 96730, internal mould of pygidium, intermediate distortion, X11.
14. UT 96725a, pygidium, L form, X10.
15. UT 96731, internal mould of cephalon, intermediate distortion, X10.

Figs. 16, 20. Ceratopygidae, gen. et sp. indet.
16. UT 96732, internal mould of partial pygidium, X6.3.
20. UT 96733, pygidium, intermediate distortion, X5.7.

Fig. 17. Trilobita incertae sedis, Specimen 2, UT 96734, partial cranidium, W form X2.5.

Fig. 18. Trilobita incertae sedis, Specimen 3, UT 96736, partial pygidium, W form, X2.

Fig. 19. Trilobita incertae sedis, Specimen 4, UT 96736b, librigena, X5.

Fig. 21. Trilobita incertae sedis, Specimen 1, UT 96737, incomplete cranidium, X7.5.

The specimen illustrated in fig. 1 comes from the upper fauna of the Climie Formation. All other specimens come from the lower fauna.

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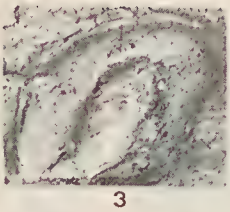
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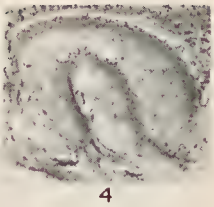
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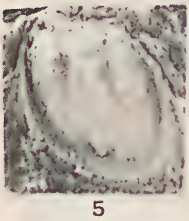
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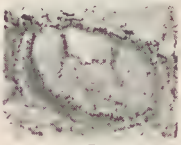
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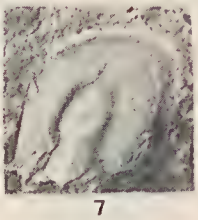
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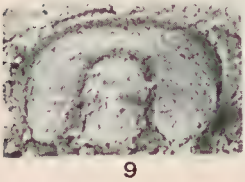
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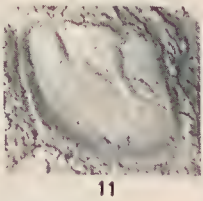
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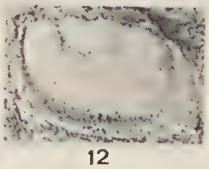
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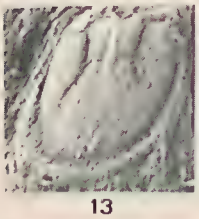
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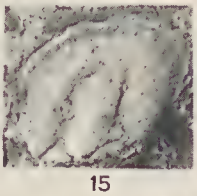
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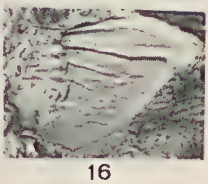
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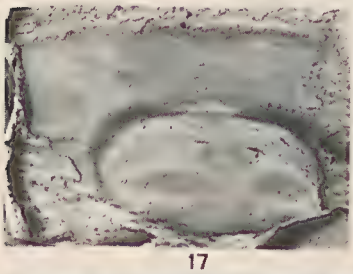
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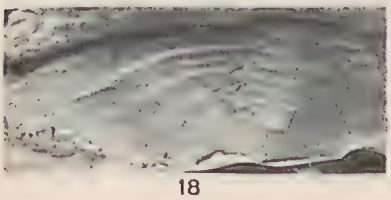
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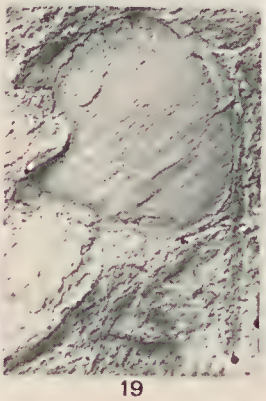
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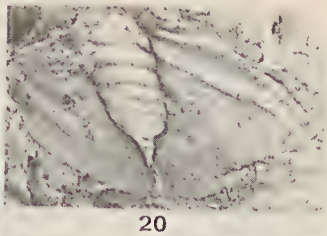
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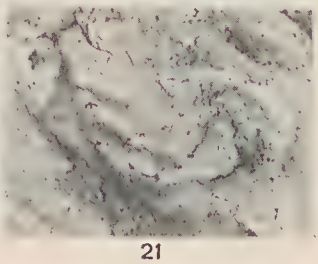
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PLATE 2

PLATE 3

Fig. 1. Trilobita incertae sedis, Specimen 5, UT 96738, internal mould of large librigena, X2.8.

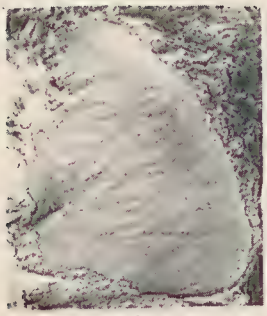
Fig. 2. *Peltura*(?) sp., UT 96739, poorly preserved almost complete specimen, L form, X5.

Fig. 4. Oleninae, gen. et sp. indet, UT 96740, poorly preserved cephalon and two anterior thoracic segments, W form, X5.

Figs. 3, 5-15. *Olenus* sp.

3. UT 96741, internal mould of librigena, X2.5.
5. UT 92678, cranidium, intermediate distortion, X5.
6. UT 96730, internal mould of partial cranidium, X8.
7. UT 96742, partial cephalon and anterior part of thorax, X2.
8. UT 96714a, small badly preserved internal mould of almost complete specimen, X7.
9. UT 96743, internal mould of pygidium and posterior part of thorax, X6.
10. UT 96744b, tectonically broken up almost complete specimen, X2.5.
11. UT 96745a, cranidium and anterior thoracic segment, X5.
12. UT 96746a, internal mould of pygidium, W form, X4.
13. UT 96747a, cranidium associated with small pygidium of *Agnostus* sp., W form, X4.
14. UT 96748, "ghosted" internal mould of almost complete specimen, W form, X2.3.
15. UT 96749, broken up thorax of at least 13 segments, X2.3.

The specimens illustrated in figures 2 and 4 come from the upper fauna of the Climie Formation. All other specimens come from the lower fauna.



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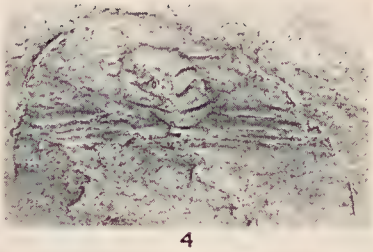

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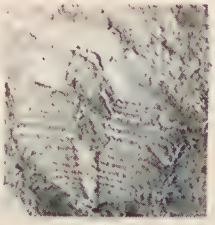

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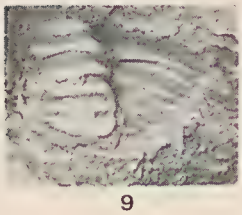

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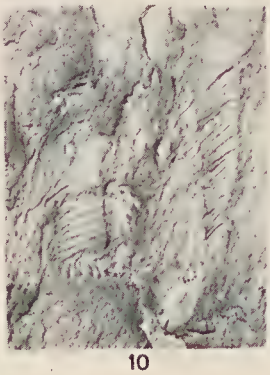

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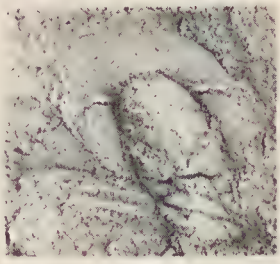

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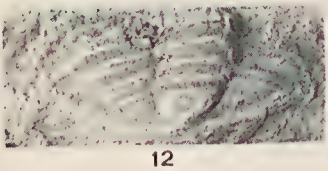

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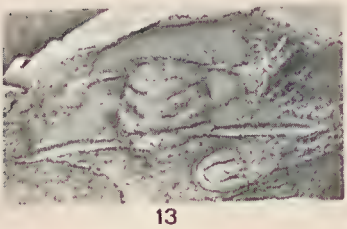

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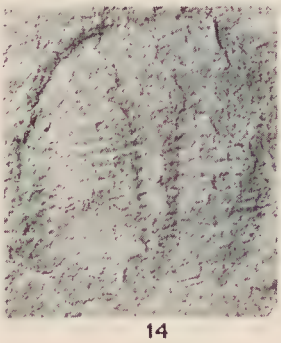

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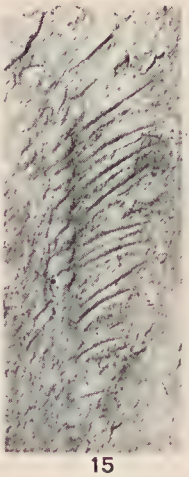

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PLATE 3

Papers and Proceedings of the Royal Society of Tasmania, Volume 112, 1978

(ms. received 8.12.1977)

A SIMPLIFIED GROWTH LINE REPLICATION TECHNIQUE

Scott Cane and Jim Stockton

ABSTRACT

An inexpensive and simple method of growth line replication is described and *Mytilus planulatus, Ostrea angasi, Cellana solida* and *Subninella undulata* are copied to provide a basis from which to assess the archaeological potential of these species.

BACKGROUND

Many species deposit mineralized tissues characteristic of and relating to predictable environmental rhythms. Examples of such deposits are found in the shell of molluscs and crayfish, in fish scales, bone, feathers, and wood. Mollusc shells are perhaps the most consistent depositors and as indexes for constructing local chronologies are of obvious archaeological value (Conover 1975).

Shell growth occurs as a result of secretion of inorganic (calcium carbonate) and organic (basically quinone-tanned protein) materials from the mantle of the shell fish. As the ultimate origin of these materials is the medium in which the shell lives, any change in that environment will lead to different patterns of growth. These growth increments will be characteristic of the particular environmental situation (Wilbur 1972). For example, tidal patterns (Conover 1975, p.11) affect the absorption and deposition of materials for shell manufacture. As most shells calcify at high tide (submergence), tidal movements will define a characteristic pattern of shell growth. This environmental growth may be further complicated by seasonal variation in temperature (Panella and MacClintock 1968, p.71), spawning cycles (Richards 1946, p.37) and intermittent, catastrophic, events, for example storm activity causing dilution of sea water with fresh and temporary sedimentation. For these reasons shell growth patterns are of significance to archaeologists. Using contemporary analogies and extensive research into the characteristics of growth lines produced under certain environmental conditions, archaeologists can make conclusive statements regarding the seasonal movements of natives (Coutts 1970, p.147) and can potentially and literally describe the coastal environment in which these people lived.

There are several techniques used to render shell growth patterns readable. Experimentation reported in this paper was done on the common edible mussel, *Mytilus planulatus*. Basically such techniques require the sectioning, polishing and replication of the shell surface. Acetate (Stewart and Taylor 1965, pp.230-32) and plexiglass peels (Frank 1960, pp.498-500) are commonly used. Both techniques require critical polishing of the shell surface and the maintenance of a perfectly plane surface. This surface is essential as these relatively rigid materials must lie in direct contact with the shell section. This is a tiring and time consuming procedure and this paper describes a technique in which the level of the sectioned surface is of less consequence.

MOUNTING

Shells that have been burnt and weathered for a considerable time are relatively friable. This, allied with their porosity renders them difficult to handle unless impregnated with a highly fluid and hard setting resin. A most satisfactory method is to half fill a typical cylindrical mould with resin. This should be allowed to partially set so the shell can then be placed on this semi-hard layer and then completely covered with resin. Before mounting, each specimen should be cleaned by washing and drying in acetone. All moisture must be removed from the shell before mounting

as moisture tends to overheat and crack the cast. An acetone bath has the added advantage of removing many air bubbles from the shell. A high quality polyester casting resin is desirable as these are hard setting, transparent and have a low viscosity. Resins used in this experiment were trade named 'Star Cast' and 'Diamond Cast' (Arbee Handcrafts Centre Pty. Ltd., Melbourne) but we would expect any high quality commercially available casting resin and 'hardener' to be suitable.

The hardness of the cast is a direct result of the amount of catalyst used to set the resin. The greater the catalyst: resin ratio the harder the cast, and vice versa. The resin must be as hard (or soft) as the shell so that a continuous surface between the two is maintained when polishing. This degree of perfection requires experimentation and is difficult to attain. The resin:hardener ratio for this experiment was 8.7 ml of hardener:100 ml of resin. This gave a curing time of 5½ hours at a temperature of 23°C. This curing time may be decreased with an increase in temperature and a more suitable time of 1½ hours was found at 70°C. An optimum level must be obtained for time to be used efficiently. Great care must be taken not to overheat and therefore, discolour and possibly crack the cast.

Mixing the resin and catalyst should be done very carefully to reduce the number of air bubbles trapped as these lessen the quality of the replica. Likewise the shell should be carefully placed in the resin so that air bubbles on the surface of the shell are not introduced. When the shell is in place, the mould and cast should be placed in a vacuum. The vacuum removes air bubbles from the cast and should be held or repeated until all air bubbles are removed. On releasing the vacuum, atmospheric pressure forces the resin into the shell (Davies and Hill 1968, p.235).

The vacuum is a very suitable method for removing air bubbles in slow setting casts. However, if the catalyst:resin ratio is too high the cast will rapidly overheat. This is because the removal of atmosphere prevents the absorption of heat given out by the exothermic setting reaction. Consequently the heat increases within the cast. This has two disadvantages. Firstly, overheating causes premature curing and the majority of air bubbles are trapped in the cast. Secondly the cast will most likely crack and if this does not occur the different cooling rates of the shell and resin will cause the cast to break from the shell surface. Replication is then impossible. (This variation in cooling rate is a problem with shells of varying thicknesses, for example, the umbo region of *Mytilus* and *Notohaliotis*).

SECTIONING

After the cast has cured, a section is cut at right angles to the growth increments (Panella and MacClintock 1968, p.67) from the umbo to the most remote point on the shell margin (Conover 1975, pp.30-1; Kioke 1973, p.24). The section may be cut with a diamond saw (Bissell 1957, p.417; Frank 1965, p.498) but this has no advantage over a hand held or band saw. The latter is in fact preferable due to the possible speed of sectioning. It is imperative that the cut be made as straight as possible. Any irregularities in the section are then removed with a flat faced file clamped horizontally in a vice.

POLISHING

When polishing the specimen it is necessary to place the abrasive material on a clean sheet of glass. This removes the risk of irregularities in the supporting surface damaging the shell surface. It is also desirable to change the polishing direction with each grade of paper so that one can see when the former scratches have been removed.

After sectioning and filing, the surface is hand polished with 600, 800 and then

1200 corundum paper. Each of these papers should be used until the scratches from the former are removed.

After the 1200 paper has been used a liquid or cream polish, e.g. Brasso or fine car polish, is used on a cloth in the same manner as the papers for at least 15-20 minutes. This time variation depends on the hardness of the cast. The quicker the resin sets the harder the cast and the greater the length of fine polishing. This treatment reduces the majority of coarse scratches but does not remove fine microscopic pits. These may be removed by finer grades of polish. Six micron diamond dust was used in this experiment; however, this procedure is time consuming and with diamond dust at $32 per 5 grams may often be impractical. Etching to remove these pits is preferable as it is cheaper and much faster.

ETCHING

At this stage the shell section is generally etched with HCl. This serves two purposes, firstly decalcifying the shell and thus raising the organic framework of the shell to be copied (Conover 1975, p.24) and secondly the etch serves to "polish" the shell surface. The process of replication described here incorporates the etching material within the stain, thus excluding this stage in the procedure.

STAINING

The only calcium stain found suitable for glue replication was Harris haematoxylin (for preparation see Friedman 1959, p.93). This stain is relatively slow and a period of 15 minutes is required to stain *M. planulatus*. The acetic acid content of this stain serves as an etch obviating the HCl etch used in acetate and plexiglass replications.

REPLICATION

The excess stain should be washed off and the surface dried with the aid of alcohol and a gentle air current. Care must be taken not to smudge the stained and etched surface. The glue used for replication was called "Mister McGloo" and was applied as evenly as possible, with the thickness being the minimum possible, as the thickness of glue decreases with setting. The only disadvantage of this method is the four hour setting time. This is however less of a disadvantage than the problems created by the polishing requirements for the other methods. When lifting the peel from the section, the peel should be removed slowly and carefully in order to preserve an accurate record of the growth structures and to ensure that parts of the glue do not stay in the shell framework. The final result is a very clear replication of the shell surface. This should be mounted on a glass slide with the copied surface up. Sticking tape is sufficient for this purpose.

APPLICATION

Having refined a suitable replication technique it was a relatively simple process to investigate the potentials of different shell species for growth line analysis. The common mussel *Mytilus planulatus;* mud oyster *Ostrea angasi;* orange rimmed limpet *Cellana solida* and wavy turbo *Subninella undulata* were investigated.

Because of the brevity of the investigation any conclusions must be considered as tentative.

Mytilus planulatus

Growth patterns in this species are very clear and the regularity and repetition of these patterns suggest a shell of considerable value to archaeologists.

Simplified Growth Line Replication

Cellana solida

The replication process for the orange-rimmed limpet is identical to that for *Mytilus planulatus*. Having studied only two individuals of this species it is difficult to make any definite archaeological suggestions. Apparently the outer (prismatic) layer of *C. solida* is eaten by a white parasitic fungus and consequently provides a very incomplete record.

The nacreous layer consists of definite bands which run obliquely to the base of the shell. We suggest these are a result of variations in growth and as only alternate 'increments' absorbed the stain we suggest these are calcium rich. The overall pattern may therefore present periods of stress and non-stress. However, these bands are not continuous and are best described as lenses of calcium rich incremental growth. Their archaeological potential is suspect and only continued research will accurately assess their potential.

Ostrea angasi

Ostrea angasi (mud oyster) is abundant in present day estuaries and estuarine middens. However, it appears unsuitable for growth ring study.

The shell is difficult to mount because the finely laminated structure holds large qualities of moisture and numerous small air spaces. In the latter case this is most important if the plexiglass or acetate methods of replication are to be used, as numerous air bubbles (which result in holes in the cast) occur at the shell edge. Premature evaporation of the solvent then occurs and the replication is very poor. In the former case the moisture often causes the resin cast to crack and this invariably occurs where a section is to be taken. The interior of these shells also contain large air spaces and these render any method of replication hopeless.

There also appear to be lenses of rich calcium material in *O. angasi*. These are very soft and make polishing difficult and, more importantly, parts of the shell are removed by the replicating material so high power magnification of the peel surface is prevented.

The crystalline structure of the mud oyster also seems to be unsuitable for growth ring study as it consists of what appear to be crystalline lamellae. This concentration of fine layers may present a shell in which the growth patterns are difficult to interpret.

Subninella undulata

The shell of the wavy turbo presents obvious embedding difficulties. Therefore experimentation was done with the operculum of the species and this proved successful. Mounting is a very simple process and the replication procedures are identical to *M. planulatus*, except the operculum requires a ½ hour exposure to Harris haematoxylin.

The interior of the operculum consists of three different structures, the outer region of which appears to have very clear growth lines. The ease of mounting the operculum and the presence of this species in a majority of coastal middens must present a species of significant archaeological value.

CONCLUSION

The use of the 'glue peel' has two primary advantages. Initially the materials required for shell replication are easily obtained and inexpensive. Secondly, this method excludes the major practical drawback - the difficulty involved in maintaining both a level and highly polished section. As the peel substance is liquid, any curves or undulations (which are exceedingly difficult to avoid) in the polished face pose no problem as this viscous liquid adequately covers all required surfaces.

The financial and practical savings of this method renders shell replication possible for any technician whether they be in well equipped laboratories or in a school class-room. The relative simplicity of replication and excellent resolution obtained with this technique render it most suitable for growth ring study.

The procedure outlined should facilitate investigation into the growth patterns produced by different environmental factors.

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OBSERVATIONS ON THE TASMANIAN DEVIL, *SARCOPHILUS HARRISI* (DASYURIDAE: MARSUPIALIA) AT GRANVILLE HARBOUR, 1966-75.

by E.R. Guiler
Department of Zoology, University of Tasmania

(with 15 tables and 14 text-figures)

ABSTRACT

Movements of Tasmanian devils in a western Tasmanian locality, Granville Harbour, were largely restricted to well defined trails and were related to actual or potential food sources.

The sex ratio varied greatly from year to year with the average over 10 years of 1:0.95. The percentage breeding success with females was only 58.9% with 2.67 pouch young/successful breeding female. Recruitment from this source into the adult groups is small.

The population was dominated by large males for most of the period with the recruitment of young, especially of males, being low in most years. Year groups survive in the population for about 5 years. The population is maintained by immigration plus occasional good juvenile recruitment. Young females have a lower mortality than males, possibly resulting from less intraspecific interactions, but the older males have low mortality and live about 1 year longer than females.

The population increased substantially in 1973 due to a high survival of earlier year groups and a low mortality. The Granville devils appear to follow a different population cycle from that of the rest of Tasmania, due to geographic isolation.

INTRODUCTION

Trapping of Tasmanian devils, *Sarcophilus harrisi* (Boitard) at Granville Farm commenced in November, 1966, and is continuing.

In the first period of trapping, between 1965 and 1967, breeding and general features of the population were examined and compared with results obtained from another group of devils at Cape Portland in northeastern Tasmania (Guiler 1970a, 1970b).

The object of this study is to observe the population structure and numbers over a period of years, assess the breeding success and recruitment to the population, and to obtain further knowledge of the movement pattern of devils on the West Coast in an area relatively untouched by agriculture.

Granville Farm was selected because it is remote from any large centre of human population and isolated from human interference, yet much of the area is accessible by 4-wheel drive vehicles so that traps can be carried around the property. A disadvantage is that the area receives so much rain in winter that vehicle work becomes very difficult and, at times, impossible.

METHODS

Devils were trapped using drop-door wire cage traps described earlier (Guiler 1970a) and, after processing the animals were released without removal from their capture site. They were sexed, weighed, measured, young examined and any peculiarities

noted prior to their release. Ear tattoos were used as a method of recognition which, combined with the distribution of the white colour patches on the flanks, chest and rump, enable all the animals to be identified upon recapture.

It was found at Cape Portland that *Sarcophilus* under intensive trapping developed a negative trap consciousness over a period of six months, the yield dropping from 0.337 devils/trap/night to 0.073 (Guiler 1970a). The latter yield returns little information, so it was decided to concentrate on intensive short-term trapping to catch the maximum number of animals for population structure information.

The traps initially were set at randomly selected sites throughout the area of the Farm and the coastal Track leading to Top Farm as well as on the surrounding country. However, based on experience (from 1968) traps were later set along the edges of paddocks, on tracks and on game trails as well as beside dead animals to yield the maximum catch. The trap line was usually about 33km long but whenever traps were set on the Top Farm Track the distance covered was about 53km.

The maximum number of devils usually were caught on the third night of each visit after which, except in 1973 and 1974, the yield declined. It was found that if a trap had not caught an animal in 3 nights at one site it would be most unlikely to do so on future nights so it was shifted to another place. Some sites never yielded a devil and were abandoned.

Throughout this work a visit is the period of a trapping expedition, a year-catch is the animals of mixed ages caught in any one year, and a site is the position of any trap or traps at any one time. A trail is a route used by animals, a track is useable by vehicles.

Granville Farm lies on an isolated part of the West Coast of Tasmania (Lat. 41° 05' E.), the nearest settlement being Granville Harbour about 2 km distant with only 3 permanent residents. The nearest township is Zeehan, 45km away, population 1,200, from which the Farm is accessible only by a rough road. The study area is relatively undisturbed and subject to minimal human interference. A satellite farm, Top Farm, lies 16km to the North and it was unoccupied during most of this study. It is connected to Granville by a coastal track which can be traversed only by 4-wheel drive vehicles and is impassable at times in winter, as well as after heavy rainfalls.

The locality, described by Guiler (1970a), consists of rain forest, gullies, cleared farm paddocks, coastal scrub and dune formations. The edges of all the paddocks have a fringe of *Pteridium* which offers excellent cover for grazing species as well as devils.

Alterations to the fauna list in Guiler (1970a) are the removal of sheep from the property, the absence of *Isoodon obesulus* Shaw and Nodder, the addition of *Ornithorhynchus anatinus* and *Tachyglossus aculeatus*, and an increase in the number of rabbits.

Detailed weather information, other than rainfall, is not available for the Granville area. The area is subject to much wind, mainly from the westerly sector, but there is sufficient shelter in the gullies and scrub for this to have little effect upon the animals living there, other than to force the grazing species to feed close to shelter.

The rainfall (table 1) is moderate but well distributed throughout the year with maximum falls occurring during July/August. The short wet days of winter allow very little drying out of the substratum so that species living there must have a high tolerance for wet and mud. The summer rainfall is highly beneficial giving green

FIG. 1. - Map of Granville Farm area, reproduced by kind permission of the Secretary for Lands. Scale: approx. 1:40,000. Legend: 1. Entrance; 2. Farm; 3. Round Hill; 4. Slaughterhouse Track; 5. Slaughterhouse Track; 6. Harrison's No. 1; 7. Harrison's No. 2; 8. Choumollier Paddock; 9. Five Acre Paddock; 10. Harrison's Back Pockets; 11. Dead Heifer Paddock; 12. Pig Farm; 13. Nicholas'; 14. Duck Creek Track; 15. Zeehan Track; 16. Old Slaughterhouse Track; 17. Granville Town; 18. Track to Top Farm; 19. Tasman River; 20. Stringer's Creek.

TABLE I

RAINFALL (IN MM) RECORDED AT GRANVILLE FARM FOR 1965-74

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
January	-	78.22	71.37	65.78	89.66	55.12	83.06	90.42	119.63	46.99
February	-	44.70	33.78	97.97	185.93	56.13	86.61	49.02	124.46	64.52
March	-	99.06	77.98	116.33	116.84	25.69	58.17	65.02	148.08	58.17
April	-	162.05	98.80	182.37	159.76	188.47	156.97	158.75	165.61[x]	151.69
May	-	134.37	58.67	307.88	171.96	185.67	188.97	92.20	231.90[x]	24.64
June	-	127.00	98.30	204.72	67.06	147.57[x]	227.84	123.44[y]	177.55	165.86
July	-	270.27	161.04	225.30	211.33	315.21[x]	77.98	239.01[y]	141.99	176.78
August	-	104.90	141.22	225.29	157.23	252.73	253.75	189.74	158.75	99.57
September	-	94.99	134.87	179.83	142.24	151.89	227.84	161.04	126.24	243.33
October	-	132.33	75.18	152.15	62.74	132.59	180.09	56.39	161.29	270.00
November	-	92.71	109.98	186.18	84.07	75.95	113.28	74.42	97.03	81.28
December	-	60.71	118.62	48.75	123.44	118.62	99.57	79.50	114.55	266.70
TOTAL	1477.52	1401.48	1179.84	1992.36	1572.24	1755.6	1754.16	1378.92	1767.0	1644.36

m = 1592.33

All figures recorded above have been recalculated in "mm" from original readings in "inches" and "points" and rounded off.
x - rain on 28 days of the month y - rain on 27 days of the month

pastures throughout the year and providing lush feed for grazers. The daily rainfall is not heavy, the greatest fall being 44.70 mm on 19 August, 1971, but some winter months have rain nearly every day. Snow has never been reported but frosts are common in winter. The microclimate experienced by the fauna can be described as mild with no great or prolonged extremes of temperature. The prolonged winter rainfall could cause discomfort to devils but it also causes stock losses providing food supplies for carrion eaters.

RESULTS

Trapping Details

The trapping details are set out in table 2. In this table, the number of animals caught each visit (Column 3) includes multiple recaptures, the sex ratios being based on this figure, whereas the sex ratio in brackets is based upon the number of unmarked animals caught in each sample.

A total of 282 devils were captured 946 times, 664 of these being recaptures (70.19%). A number of devils were caught on only one occasion (table 3), this percentage ranging from 0 to 39.28 in 1969. Although 50% of the 1975 catch were not retrapped, this percentage can be expected to reduce after subsequent trapping. There was no sex bias in the total number of devils never again trapped though a very strong difference was detected in 1968, 1969, 1971 and 1974. However the adult population showed a strong likelihood that males would be less likely to be recaptured than females whereas the juvenile female was found to be less likely to be recaptured than the male. No such sex difference was detected in either adults or juveniles which were recaptured once during a trapping visit and were not captured subsequently (table 4).

Throughout each visit the number of animals trapped per night declined until it reached such a low level that the return per trap yielded insufficient information commensurate with the effort involved.

TABLE 2

DETAILS OF *SARCOPHILUS* TRAPPING AT GRANVILLE, 1966-74
The figures in brackets refer to new animals only

Date of visit	No. of Traps	Total animals caught	No. of Individuals	No. of new animals	% of new animals	Males	Females	Catch/Trap/Night Total	Male	Female
18-23/11/66 10-12/12/66	396	62	40	40	100.0	27(18)	35(22)	0.157	0.068	0.088
30/6-5/7/67	229	46	45	30	66.6	28(16)	18(14)	0.200	0.122	0.078
15-19/11/67	357	19	18	5	27.7	5(1)	14(4)	0.053	0.014	0.039
26/10-1/11/68	331	31	23	15	65.2	10(6)	21(9)	0.093	0.032	0.063
7-11/2/69	367	27	23	12	52.1	12(8)	15(4)	0.074	0.032	0.041
30/5-3/6/69	209	27	17	9	52.9	14(5)	13(4)	0.129	0.067	0.062
16-19/11/69	202	36	17	7	41.1	14(4)	22(3)	0.178	0.069	0.109
3-7/11/70	233	29	20	11	55.0	16(7)	13(4)	0.124	0.068	0.056
30/10-4/11/71	244	37	34	19	55.9	18(6)	20(12)	0.151	0.069	0.082
21-27/11/72	296	45	39	23	58.9	25(13)	20(10)	0.152	0.084	0.067
12-19/5/73	391	106	63	32	50.8	65(18)	41(14)	0.271	0.166	0.104
30/10-3/11/73	335	74	57	23	40.3	42(10)	32(13)	0.221	0.125	0.095
28/5-3/6/74	387	163	99	27	27.2	106(13)	57(14)	0.421	0.273	0.147
2-10/11/74	634	126	71	13	18.3	64(4)	62(9)	0.198	0.100	0.098
25-31/11/75	522	118	69	16	25.5	69(9)	49(7)	0.226	0.132	0.094
	5133	946	635	282			mean =	0.177	0.092	0.082

The catch was lowest in November, 1967, when only 19 animals, a yield of 0.053 animals per trap per night, were captured. Only one of these animals captured was recaptured on this visit although all of the five new animals which were caught were retrapped on later visits. There was no apparent reason for the low catch during this visit, particularly as devils' tracks were numerous throughout the locality.

The catch per trap per night was greatest during 1973 and 1974 reaching 0.421 or almost one animal in every two traps, the mean return over the 1966-75 observations being 0.1766. The increase in 1973 and 1974 may be due to more successful trap siting since 1968 as more was known of the travel routes. However, on each visit the trapping was continued until only retrapped animals were caught so that most of the population were sampled each visit. The return for effort increased from an average of 0.125 in 1966-68 to 0.197 in 1971-73 although the number of traps set declined from 1313 to 1266. This can be interpreted as a sign of a growing population.

The percentage of unmarked devils caught each trip varied around 51.5 from 1967-73 but was lower in 1974.

The yield of new males and females over the period was almost the same, 0.0273 males and 0.0295 females per trap. The total yield of males including retraps, 0.0947, was slightly higher than that of females (0.0815). A substantial sex bias in trapping can be detected in some years, as in November, 1975, November, 1968, and November, 1969. However, in view of the considerable changes in sex ratios observed from year to year it is doubtful if these figures are of any real significance.

A number of animals were caught twice and others were caught on a number of occasions, one male animal, A123, being caught 15 times. Some individual animals were found to show a positive trap consciousness as in the case of a male, A176, which was

TABLE 3

NUMBER OF *SARCOPHILUS* WHICH WERE RECAPTURED ONCE during the year of their original capture and never recaptured subsequently.

	New devils caught	Adults M	Adults F	Juveniles M	Juveniles F	Total	Percentage of Col. 1.
1966	40	6	2	2	5	15	37.5
1967	35	3	1	1	3	8	22.85
1968	15	3	0	0	1	4	26.6
1969	28	7	1	1	2	11	39.28
1970	11	0	0	0	0	0	0
1971	19	1	1	0	2	4	21.05
1972	23	1	0	0	1	2	8.7
1973	55	2	5	3	0	10	18.11
1974	40	0	1	0	4	5	12.5
1975	16	0	0	1	1	2	12.5
		23	11	8	19	61	
		$\chi^2=4.24$		$\chi^2=4.48$			

TABLE 4

NUMBERS OF *SARCOPHILUS* CAUGHT ONLY ONCE. Granville, 1966-75.

	Adults M	Adults F	Juveniles M	Juveniles F	Total
1966	4	3	0	1	8
1967	4	3	1	0	8
1968	0	0	0	1	1
1969	1	1	1	3	6
1970	0	1	0	0	1
1971	0	0	0	0	0
1972	0	1	0	0	1
1973	1	3	3	0	7
1974	4	3	3	7	17
1975	0	0	1	0	1
Totals	14	15	9	12	50
	$\chi^2=0.03$		$\chi^2=0.43$		

caught on six consecutive nights in May, 1973, all in the same locality.

Examination of the trap yield of the different trapping areas (table 5, and Appendix 1) shows that the catch may vary from year to year and also that some areas give much better catches than others. Thus the catch at Round Hill which was high in the early period from 1966-69 declined to such a point that so few devils were caught that it was unprofitable to trap there.

The catching index at certain localities such as the Slaughterhouse is high although the total number of animals caught there is low due to the restricted area in which traps can be set so that a catch of one or two animals per week in one trap leads to a false impression of the number of devils operating in the area.

Round Hill during the period 1965-69 was dominated by female devils by a ratio of 2:1. No other sex differences in trapping were recorded although slightly more males than females were caught on the Zeehan Track.

It was not always possible to trap each area on every visit as weather and track conditions made some places inaccessible, nor was it always possible to set many traps at Granville town as during weekends and holiday periods there was too much interference with traps by dogs and humans.

The table shows that certain areas such as the Dead Heifer Paddock, Pig Farm, Granville Town, Zeehan Track and Nicholas' Paddock yield consistently high catches of devils but these are all surpassed by the 9 acre paddock which has a very high yield from a small number of traps. Most of the animals caught in this paddock were trapped at either a trail under one place in a fence and at a dam across a creek. Trapping the remainder of the paddock has been fruitless, and this experience led to the redesign of the experiment in later years to trap only those stations which yield good catches since it was apparent that devils follow well defined routes and any traps set away from these routes will be of little value.

TABLE 5

CATCHING INDEX FOR *SARCOPHILUS* AT THE MAIN TRAPPING AREAS, GRANVILLE 1965-74. A dash indicates that no traps were set in that locality in that year. The figures are given as catch/1000 traps.

	1965-8	1969	1970	1971	1972	1973	5/1974	11/1974	Mean
Slaughterhouse	50	5	166	-	333	0	-	153	118
Top Farm Track	231	70	-	-	166	102	-	-	142
9 Acre Paddock	250	-	-	333	285	397	764	208	373
Round Hill	153	148	95	67	-	111	-	-	115
Harbour Paddock	48	0	-	41	-	166	-	83	68
Granville	142	333	-	-	-	455	-	250	295
Main Road	42	-	-	166	250	143	-	-	120
Zeehan Track	125	307	-	296	62	363	370	155	240
Harrison's No. 1	133	34	125	-	333	214	150	56	149
Harrison's No. 2	-	-	66	-	-	111	-	159	112
Harrison's Back Pockets	200	173	222	77	28	215	245	139	162
Nicholas' Paddock	153	183	0	-	181	-	552	177	208
Dead Heifer	-	222	350	222	272	230	591	171	294
Pig Farm	-	91	-	-	380	189	574	317	310
Duck Creek Track	100	59	-	0	214	-	230	389	165

Growth of Individuals

Devils are born in April-May and the pouch young can be aged by using various criteria as described by Guiler (1970b). Post-pouch but non-independent devils of up to seven months can be aged by the stage of eruption of the teeth (Guiler and Heddle, 1974). At twelve months of age, during the next breeding season in which they take no part, the young animals weigh about 2½kg. After 12 months of independent life, in November, immature devils weigh about 4.0-5.0kg. The weights of these animals of known age were followed throughout life and used to construct the weight-age relationship curves (fig. 2).

Initially, females are heavier than males but by 18 months this is reversed. There is a large Standard Deviation particularly for males and some individuals showed very great weight increase over a short time so that it is very inaccurate to use weight as an index of age after 18 months. For example, a male, A167, increased in weight from 2.28kg to 7.27kg in six months and a male, A168, from 3.5kg to 9.4kg also in six months. Therefore the age of unmarked devils can only be based upon their external appearance, pelage conditions and the size of the animals and they can only be age-classed as either adult or old animals, the latter being distinguished by lack of postero-dorsal fur, frequently heavy scarring on the face and body, size and sometimes by rheumatism or other neuro-muscular disabilities.

Composition of the population by weight and sex

The mean weight of 100 male devils was 6.91kg, while that of 100 females was 5.39kg. The mean weight of 50 adult males was 8.171kg and that of the same number of females was 6.126kg, and 50 juveniles of each sex showed that the males were slightly heavier, 4.76kg, compared to 4.37kg. Thus, the males are heavier throughout most of the life of the animals, those of 7.75kg or greater usually being males (fig. 3).

The population was arbitrarily divided into six weight groups of which groupings of less than 5.0kg represent immature animals. The weight composition of the population both as a whole and by sexes is considered later (figs. 5-10).

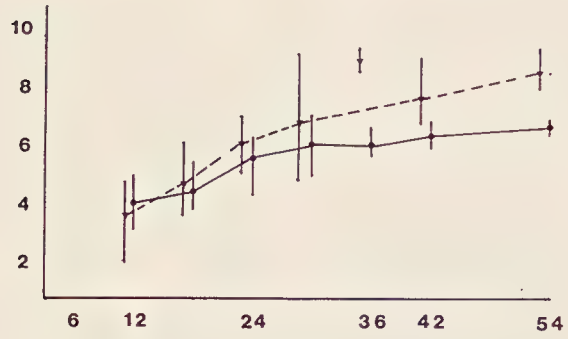

FIG. 2. - Weight (kg; vertical axis)/age (months) relationship for *Sarcophilus harrisi* at Granville. Based on animals of known age. Bars represent the range.

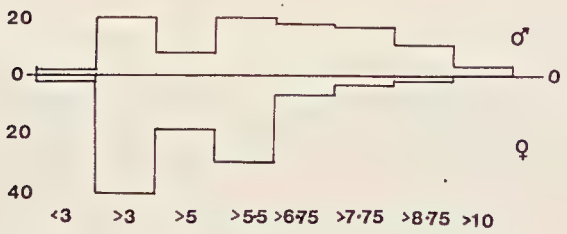

FIG. 3. - Weight distribution (horizontal axis) of 100 each males and female *Sarcophilus* at Granville.

TABLE 6

MEAN WEIGHTS (IN KG) OF BOTH SEXES AND OF THE TOTAL POPULATION (m), EXCLUDING POUCH YOUNG, OF *SARCOPHILUS HARRISI*, GRANVILLE 1966-75.

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Male	7.77	8.01	8.57	7.82	7.59	8.00	7.51	7.50	7.02	6.80
Female	5.85	6.68	6.44	6.28	6.53	6.33	6.31	5.97	5.92	5.79
m	6.81	7.35	7.51	7.05	7.06	7.17	6.91	6.74	6.47	6.39

The mean weight of the population varies from year to year as also does the weight of each of the sexes (table 6). An unusual situation occurred in 1975 when a number of known survivors from earlier year catches weighing less than 5kg were caught. These would have been classed as immature (weight basis) had they not been known to be of adult age. Furthermore, some of the devils caught in 1975 had reduced body weights compared to those of previous years.

MOVEMENTS

Devils were shown earlier to move up to 16km in a night, although the majority of the population did not travel so great a distance. In addition, it was shown that devils are non-territorial in habit, other than the territory around the immediate vicinity of their food and their mate during breeding (Guiler 1970a). These conclusions have been supported by the results of the present study. Movements of devils were identified in the field by the frequency of usage of trails and by scats and these observations were then confirmed by trapping.

Trapping at Granville revealed that, in general, the devils from the southern end of the property did not move directly up the coast but travelled inland to the eastern paddocks which served as a general mixing area for all of the animals in the district. Similarly devils from the northern parts moved to the east paddocks but not to the southern end of the Farm.

The movement around the Farm is by well defined routes, usually tracks, cattle or game trails. These routes are closely followed by devils and traps placed only one metre distant from the route frequently fail to catch any animals.

MOVEMENTS OF THE SEXES

Some difference was found in the movements of the sexes and, particularly, the Zeehan track area has yielded more information on the movements of females than males. The number of males and females caught and retrapped on the track is approximately the same, but 33% more females than males were retrapped in other localities. The Dead Heifer-Back Pockets-Pig Farm area furnished more male than female retraps.

Males were recaptured a shorter distance from their previous place of capture than females, 170 male recaptures averaging 1.82km from their previous capture station, while 144 female recaptures averaged 2.34km. The greater distance moved by females possibly was the result of greater foraging activity by these animals during the period of maintenance of the young.

SEX RATIO

The sex ratio of the adults, juveniles and pouch young varies considerably from year to year (table 7) as in 1975 when 1.35 adult males were caught for each adult female and in 1971 when seven female juveniles were trapped to three males. The sex ratio varies at different times during one year as in 1967 when the sex ratio of adults in July was found to be 1:0.87 and in November 1:4.0 and also in May, 1973, the sex ratio was 1:0.77 and in November, 1:1.3. These differences may be real or they may be artificial from the small sample sizes. The sex ratio of the whole population excluding pouch young from 1966-75 was 1:1.03 while that of the adults is 1:0.86 and that of the juveniles is 1:1.90 and that of the pouch young is 1:0.94. Chi squared test show that neither the adult nor pouch young ratios differ significantly from 1:1 but the juveniles depart significantly from this ratio. This would suggest a change in the sex ratio from almost equal sexes in the pouch young to a female dominated juvenile population and then a return to a population which, although not significantly different from 1:1 ratio does show a tendency to male dominance in the adults, although the sex ratio of the juvenile and adult populations taken together shows about equal numbers of each sex. The change in sex ratio may be attributed to either a behavioural reaction by the juveniles towards the traps or the sex ratio may be, in fact, different. It is shown earlier that there is no sex bias in the trapping and the juvenile sex ratio may well be a true record of the sex numbers of the population.

TABLE 7

SEX RATIO OF THE GRANVILLE POPULATION OF *SARCOPHILUS HARRISI*, 1966-75.
The total population does not include the pouch young.

	Total Pop.	Adults n.		Juveniles n.		Pouch Young n.	
1966	40	25	15:10 = 1:0.60	15	3:12 = 1:4	20	12:8 = 1:0.67
1967	44	29	14:15 = 1:1.07	15	4:11 = 1:2.75	39	14:25 = 1:1.79
1968	24	20	11:9 = 1:0.82	4	0:4 = 0:4	20	12:8 = 1:0.67
1969	57	45	20:25 = 1:1.25	12	5:7 = 1:1.40	38	11:27 = 1:2.45
1970	21	18	10:8 = 1:0.80	3	1:2 = 1:2.00	20	12:8 = 1:0.67
1971	29	19	11:8 = 1:0.73	10	3:7 = 1:2.33	16	10:6 = 1:0.60
1972	35	28	18:10 = 1:0.56	7	2:5 = 1:2.50	28	16:12 = 1:0.75
1973	94	65	31:34 = 1:1.10	29	17:12 = 1:0.71	43	29:14 = 1:0.48
1974	109	88	49:39 = 1:0.80	21	6:15 = 1:2.50	32	17:15 = 1:0.88
1975	67	61	35:26 = 1:0.74	6	1:5 = 1:5	18	8:10 = 1:1.25
			214:184 = 1:0.86		42:80 = 1:1.90		141:133 = 1:0.94
			χ^2 = 2.26		χ^2 = 11.84		χ^2 = 0.23
			0.20 p 0.10		p .001		070 p 0.50

TABLE 8

CONTINGENCY TABLE ANALYSIS OF INDEPENDENCE BETWEEN SEX-YEARS FOR ADULT *SARCOPHILUS HARRISI* AT GRANVILLE, 1966-75.
The numbers in brackets are the expected values (column total x row total/grand total).

	Males	Females	Total	x^2
1966	15 (13.4)	10 (11.6)	25	0.41
1967	14 (15.6)	15 (13.4)	29	0.35
1968	11 (10.8)	9 (9.2)	20	0.01
1969	20 (24.2)	25 (20.8)	45	1.58
1970	10 (9.7)	8 (8.3)	18	0.02
1971	11 (10.2)	8 (8.8)	19	0.13
1972	18 (15.1)	10 (12.9)	28	1.21
1973	31 (34.9)	34 (30.1)	65	0.95
1974	49 (47.3)	39 (40.7)	88	0.13
1975	35 (32.8)	26 (28.2)	61	0.32
	214	184	398	5.11

χ^2_9 = 5.11;not significant

There was no significant variation in sex ratios for adults over the sampling period (table 8).

REPRODUCTION

Some details of the reproduction of *Sarcophilus* were outlined by Guiler (1970b) who found that the breeding success of *Sarcophilus* varied from year to year. The percentage breeding success at Granville is high with up to 80% of the eligible females carrying pouch young, the mean breeding success of the females being 58.1% (table 9). The years 1967, 1969, 1973, and 1974 were most productive of pouch young though only one of these years (1967) coincided with the highest percentage breeding success amongst the females.

The number of young produced in any year is high relative to the total mature

TABLE 9

REPRODUCTION IN *SARCOPHILUS HARRISI* AT GRANVILLE HARBOUR, 1966-75.
A mature female is one judged to be mature based upon weight and size.

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	Totals
Total no. of females	22	25	13	28	9	14	14	40	54	31	250
Total mature females	16	16	10	21	6	8	10	29	26	25	167
Females with young	8	12	7	14	4	5	8	18	15	6	97
Females without young	8	4	3	7	2	3	2	11	11	19	70
Percentage success	50	75	70	66.6	66.6	62.5	80	62	57.69	31.5	58.1%
Number of young	20	39	20	38	12	16	16	43	37	18	259
Mean no. of young/female	2.5	3.25	2.85	2.71	3.0	3.20	2.0	2.39	2.46	3.00	2.67

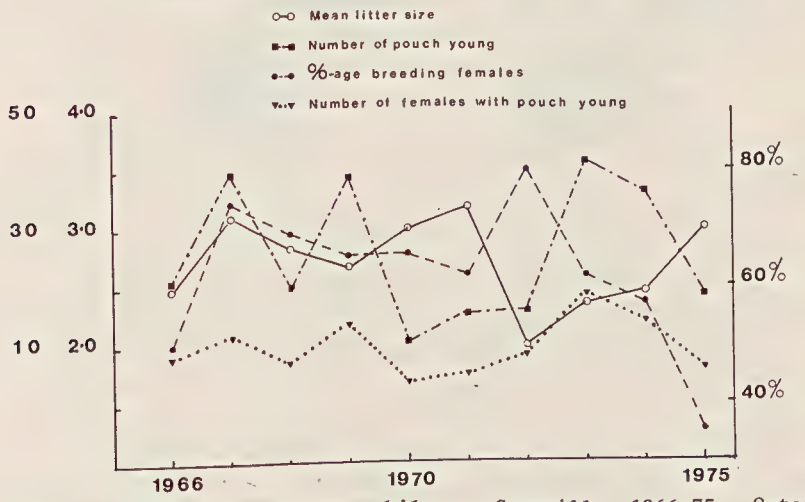

FIG. 4. - Breeding data, *Sarcophilus* at Granville, 1966-75. Outer scale on left side abscissa refers to the number of females with pouch young as well as to the number of pouch young. Inner scale is the mean litter size.

female population in the area. Breeding in 1975 was very unsuccessful with only 31.5% of mature females carrying young although the mean litter size was high (3.0). The number of pouch young is related to the number of breeding females but the percentage breeding success does not follow the number of breeding females in the population (fig. 4).

The mean number of young produced per female and the breeding success each year showed no correlation with rainfall during the months of mating (February-March) or birth (March-April) indicating that breeding in *Sarcophilus* is largely independent of normal weather conditions.

Breeding in the female does not commence until the second breeding season after that in which the female herself was produced, although a few females may carry young in their first year. Some females apparently are never successful in breeding as shown by A692 which was caught each year between 1970 and 1974 inclusive and was not found to be carrying pouch young.

Females breed for about four years and then may still be in the population for a fifth year but not carrying young. Illness may prevent breeding - female A344 had no pouch young in 1967 possibly due to a large cyst on one nipple but the animal bred successfully in 1968 and 1971 when the cyst was not present. In one instance, L. Hughes (pers. comm.) found a uterine cyst in a pseudopregnant female.

A few individuals breed out of phase with the rest of the population as shown by A816, captured on 14/5/1973, having 2 nipples which had been used to suckle large young within about a month, the nipples being much larger than those of the lactating females of the year. Green (1967) reported out of phase young from Icena and Guiler (1970b) found non-synchronous breeders at Cape Portland (N.E. Tasmania).

Young females carrying their first litter have a mean number of 2.0 young and mature animals during their second to fourth seasons have a mean of 3.6 pouch young whereas old animals have 2.0 young in their last season. Assuming a breeding life of five years these figures give a reproductive potential of 14.8 per female which is fairly low. This figure is lower if the mean litter size for all ages (2.67) is calculated with a breeding life of 4 years giving a reproductive potential of 10.68.

LONGEVITY

Devils do not live for a long time in captivity, approximately 6 years being recorded by Flower (1931). However, this would appear to be about the normal life span for an individual as Granville trapping records show that Animal A340, a male, captured on 1/7/1967 as a 3.4kg juvenile of about 12 months age, was last captured on 1/2/74, as an aged, 6.7kg animal. This devil probably was born in March-April of 1966 and was about eight years of age when last captured. Two animals, A325, male, and A344, female, were both estimated on the same criteria to be 6½-7 years of age. The structure of the population weight histograms suggests that males live longer than females and that only a few devils live longer than six years.

EMIGRATION

No evidence could be found of any substantial emigration from the area of Granville-Top Farm. Extralimital trapping at Tasman River, Stringer's Creek and the button grass plains on the Zeehan Track did not produce any marked animals, although a few new individuals were encountered.

PREDATION

Adult *Sarcophilus* do not have any predators in the natural situation, but feral dogs are capable of killing devils. There is both field and experimental evidence that small devils may be deprived of food by large adults, if not actually killed by them (Buchmann and Guiler 1977). No other predators are known, although the small juveniles may well be killed by *Dasyurops maculatus*.

COMPOSITION OF EACH YEAR'S CATCH

The weight-sex composition of each year's catch is described below, together with details of its composition in relation to previous years and the fate of the catch in subsequent years.

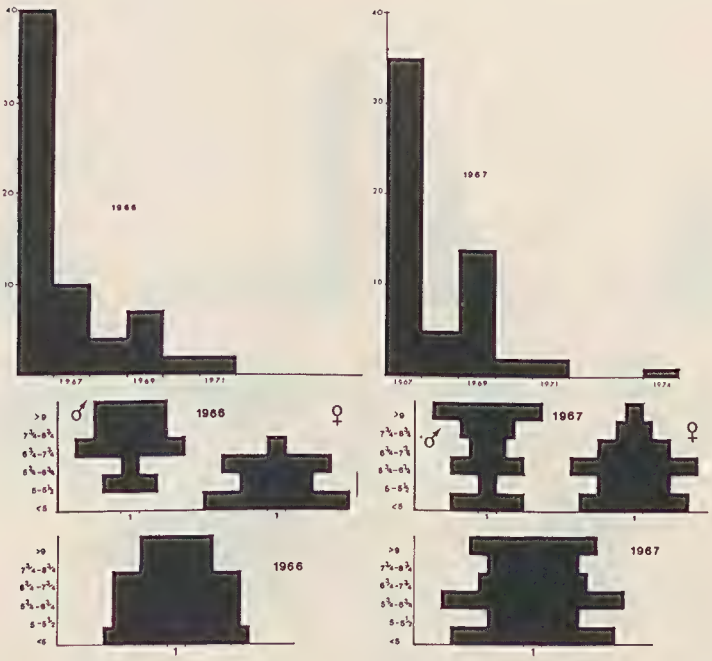

FIG. 5. - Population structure and survival of catch, 1966 and 1967. The lower histogram shows the total population, middle histogram shows the composition by sexes and the top shows the survival of the cohort into subsequent years. The population in this and Figs 6-10 is divided into 6 weight classes (in kg) as shown only on this Figure. In every case in the lower row of histograms males are shown to the left and females to the right of the axis, and in the histograms in the next row upwards males on the left and females on the right histogram.

1966 (fig. 5)

The population showed a good balance between large, medium sized and small animals, but the size distribution in relation to sex showed that all of the small animals of less than 5kg were female. Further, the two largest groups, greater than 7.75kg, were composed exclusively of males. Most of the females of this year were small animals.

The 1966 catch was recaptured in every year until 1971 after which they ceased to appear in the population, but was represented by only one individual in 1970 and 1971.

1967 (fig. 5)

Medium sized devils dominated the population in this year although there were a number of 9kg animals present, one of these being a female, the only animal of that sex to exceed 9kg. The male population in contrast to that of 1966 showed some juvenile recruitment, but again, the largest part of the male group consisted of heavier individuals. The female devils showed good juvenile recruitment with the 5.75 - 6.75kg animals forming the largest group in the population. The large males and

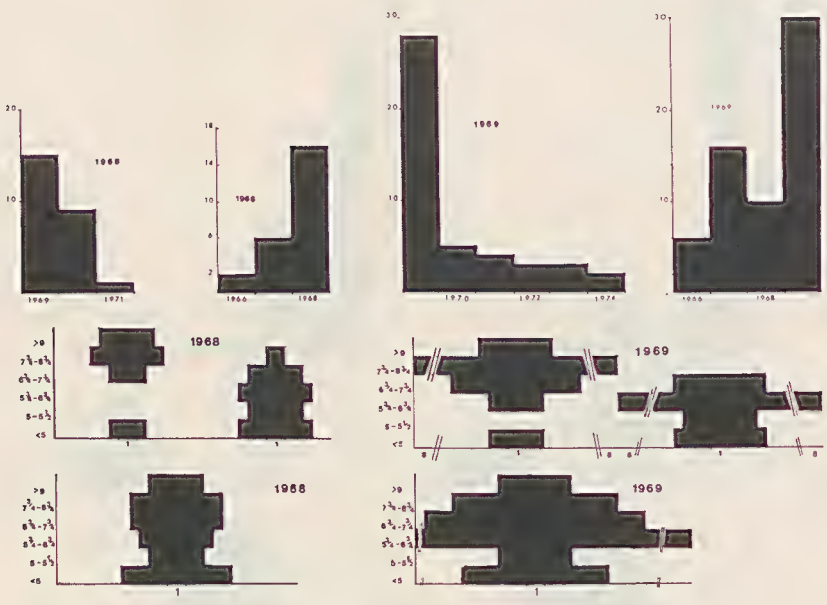

FIG. 6. - Population structure and survival, 1968 and 1969.
Conventions as in Fig. 5.

females formed a very broad summit to the population pyramid.

This catch was very strongly represented in 1969 and although one individual male was recaptured in 1974, most of the animals were no longer seen after 1971.

1968 (fig. 6)

Larger devils again were the most numerous group. However, although recruitment of young apparently was satisfactory, there was a dominance of females in the 5kg group as well as in all groups up to 6.75kg. The male population thus consisted of large animals, a continuation from 1967, together with a very small immature component. The females were of a more balanced composition with good recruitment. The juveniles were composed mainly of females and the next two larger size groups were exclusively female.

The 1968 catch, apart from the new animals of the year, was composed of representatives of the 1966 and 1967 catches and was short-lived, none of the animals being retrapped after 1971.

1969 (fig. 6)

Recruitment of females was greater than that of the males, although the latter showed better recruitment than in 1968, but the number of animals of 5.5kg also was low, probably following the poor recruitment of 1968. Females of 5.75 - 6.75kg formed the largest single group in the population with large males also present in substantial numbers, the heavier male groups forming the largest groups of the population. The population was dominated by large animals of both sexes with young males poorly represented.

This very strong group was identified until 1974 with representation in each year, and contained animals from 1966 with the strongest representation from 1967.

1970 (fig. 7)

Few devils were caught compared to 1969 and the population showed some imbalance with two weight groups poorly represented. Large females greater than 7.75kg were absent and this size group was poorly represented in the males. Some large males were still present, survivors from 1969, forming a substantial part of the male population. Recruitment in both sexes was poor.

These animals survived well and were present in substantial proportions in nearly all years up to and including 1975, although the year 1972 had few members of this group. Representatives from all the previous catches were included in this year.

1971 (fig. 7)

The total population of devils was in a more balanced state although there was considerable imbalance in the male group greater than 9kg, which formed the greatest single group of the male population, and these, together with the next group, formed the largest part of the total population. The young female group was poorly represented, probably resulting from the poor recruitment of the preceding year. Recruitment of males was low, that of the females being satisfactory.

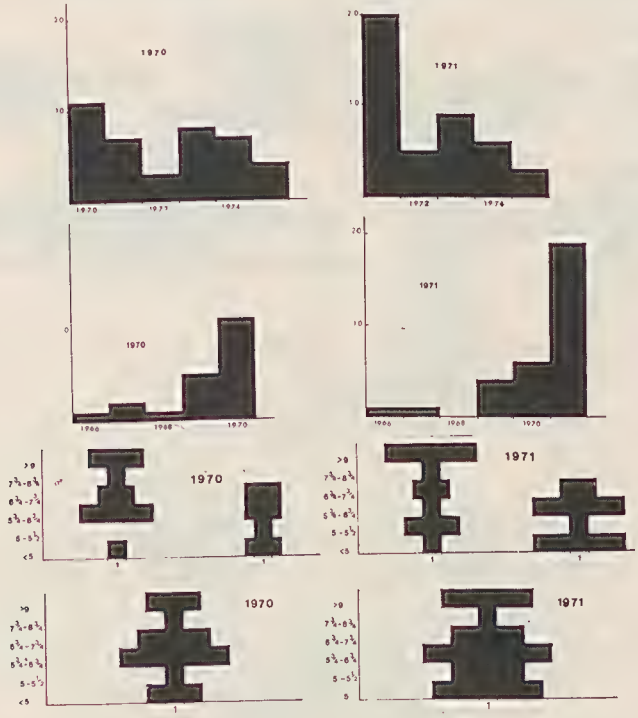

FIG. 7. - Population structure and survival, 1970 and 1971. Conventions as in Fig. 5 adding top right histogram shows the composition of the cohort.

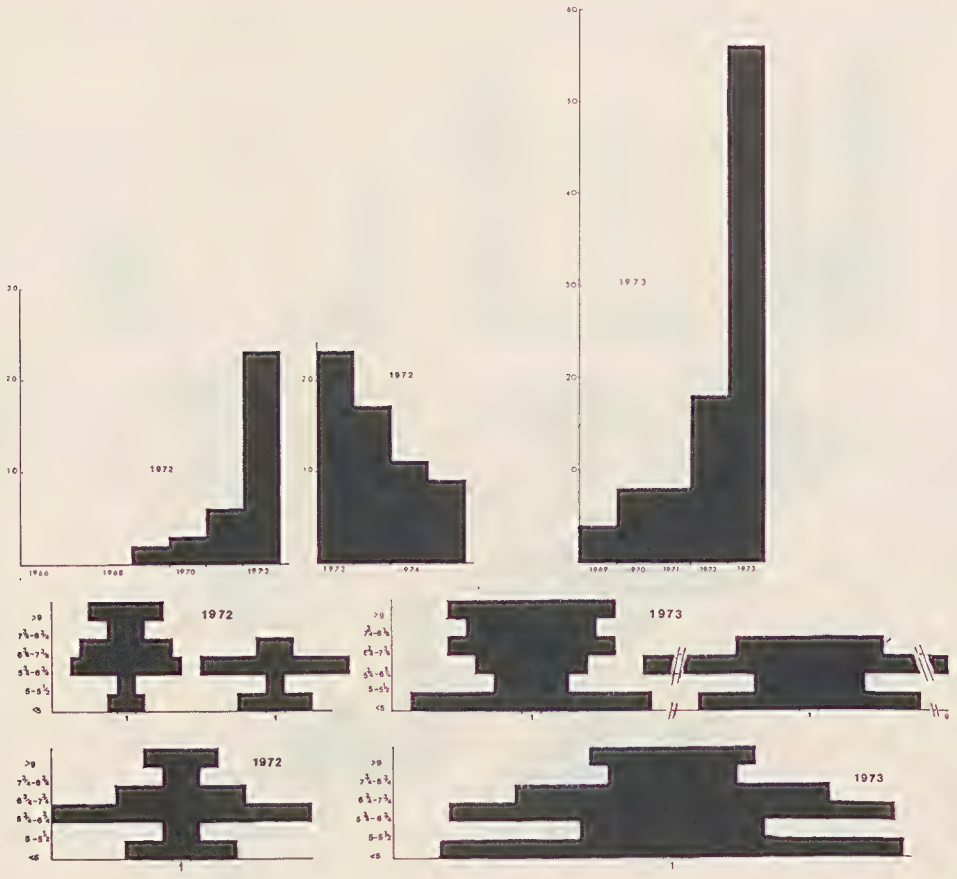

FIG. 8. - Population structure, composition and survival, 1972 and 1973. Conventions as in Fig. 7.

The catch was composed of representatives from all previous years, except those of 1968 which was previously noted as being a short-lived year catch. These devils survived in number until 1975.

1972 (fig. 8)

The number of animals in the Granville area increased this year, mainly because of the appearance of a large number of 5.75 - 6.75kg animals which partially was offset by a low number of young animals. The number of smaller animals was low in both sexes, the two largest size classes being represented only by males. In general both the male and female populations were dominated by medium sized animals. Most of the animals in this year were new to the area and the years 1969-71 were the only earlier groups represented.

This catch was strongly represented in 1973 and again in 1974 showing much better survival than in any other years.

Both the composition of the catch and the weight composition histograms suggest a

large number of new animals in the population, this conclusion being supported by the field records of new captures. As the juvenile recruitment was poor, this was probably due to immigration.

1973 (fig. 8)

The total number of animals increased very substantially due to a general increase in numbers of each weight group rather than to an increase in any particular group or groups. The population showed a good balance between the old, mature, and juvenile weight groups, but the males showed a predominance of large animals, although there was good recruitment of young males. The female production did not have any large animals greater than 7.75kg whereas males of the two heaviest groups formed the largest proportion of the population. Small adult males were poorly represented following on the low recruitment in 1972. Juvenile recruitment was very good in both sexes.

The catch was formed from all groups from 1969. No purpose is served by following the survival of these animals at the present time, although 40 of these animals were caught in 1974 and 19 in 1975.

1974 (fig. 9)

The increase in population found in 1973 continued due largely to a very strong 5.75 - 6.75kg group compsedd almost equally of both sexes. With the exception of this group, the total population showed a very balanced weight group composition. The

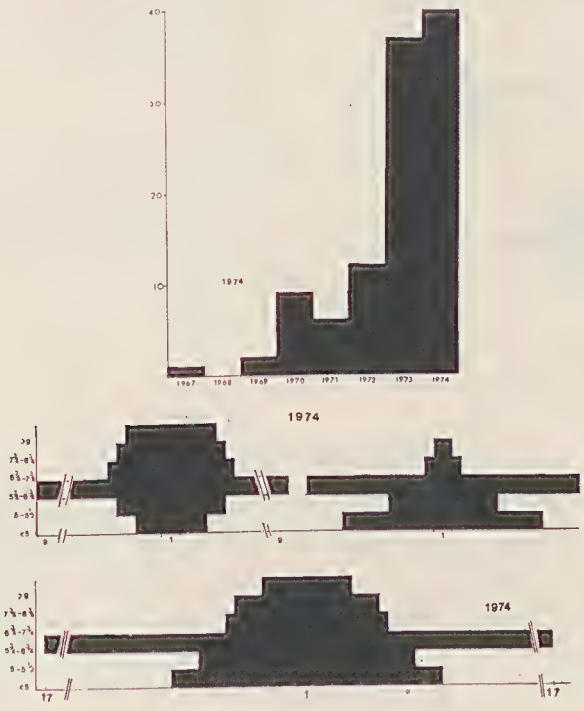

FIG. 9. - Population structure, composition and survival, 1974. Conventions as in Fig. 7.

female population showed good recruitment and a good balance in the larger animals, whereas the males again showed relatively poor recruitment and, apart from the weight groups 5.75 - 6.75kg, a tendency towards "top heaviness" in the population structure.

There was a very strong survival from the 1973 catch, together with representatives of all earlier years except 1966 and 1968; with the 1970 catch being more strongly represented than might be expected. Only eighteen of the 1974 animals were recaptured in 1975.

1975 (fig. 10)

This year's catch was unusual in that the largest number of animals caught were not from the new captures of the year, but from a previous year (1974) and, further, in that the 1973 component also was larger than that of 1975. The survival of the 1973 animals as noted for 1974, continued into 1975, but no animals earlier than 1970 were found although there was a high survival of the 1972 group.

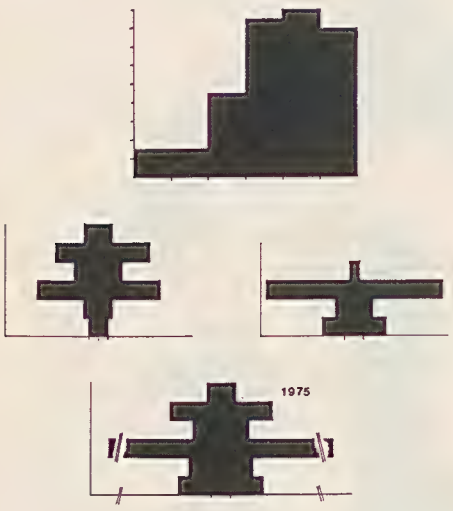

FIG. 10. - Population structure, composition and survival, 1975. Conventions as in Fig. 7.

The heavier groups of animals were few in number, especially the females, none of this sex greater than 7.5kg being caught. The very large representation of 5.5 - 6.5kg animals seen in 1974 again occurred, but there was no evidence of the 1974 animals of this size entering the population as larger animals.

The recruitment of both sexes was poor, especially the males, as shown by the small sizes in the 1975 catch.

Although it is not brought out in the figure, this year also was unusual in that the mean weight of each sex was lower than in previous years and, more importantly, some of these low weights of less than 5kg were animals recaptured from previous years and known to be more than 2 years of age.

ADULT/JUVENILE RATIO

The percentage of adults to juveniles in the Granville population is shown in table 10 to vary from year to year between a very high maximum of 91% and a minimum of 61.53% with a mean of 76.18%, thus emphasising the dominance of adults in the population. In no less than 5 years more than 80% of the population was composed of adults. These percentages are high in comparison with other carnivores. Schaller (1972) found from 40-57% adults in the lions of the Serengeti and Rudnai (1973) recorded about 25% adult lion in Nairobi.

RECRUITMENT

Recruitment to the Granville population is from two sources - immigration or by reproduction. Captured unmarked adult devils may have migrated into the area or may

TABLE 10

PERCENTAGE OF ADULT TO JUVENILE *SARCOPHILUS HARRISI* at Granville Harbour, 1966-75.

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	Mean %
% Adults	61.53	65.90	83.33	78.94	85.71	65.51	80.00	69.14	80.75	91.04	76.18

have remained unmarked from a previous trip. No immigration estimate could be made for immature animals since these could have been recruited either from breeding within the area or by immigration of young from surrounding areas. All such immatures were considered to be a result of reproductive recruitment whether from within or outside the study area (table 11).

The loss of young devils is very high, ranging from 94.8% to 45.0%, which may be expected from the population structure and mortality curves presented elsewhere. It is evident that in one year, 1972-73, the number of immatures exceeded the number of pouch young by 81%, which indicates a substantial immigration. Apart from this one occurrence, the number of immatures which enter the population is low, indicating a generally low rate of successful reproduction throughout the Farm and its environs.

TABLE 11

RECRUITMENT OF IMMATURE *SARCOPHILUS* FROM THE KNOWN POUCH YOUNG OF THE PREVIOUS YEAR, GRANVILLE, 1966-75.

	1966-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	Mean
Pouch young	20	39	20	38	12	16	16	43	37	241
Immatures	10	2	11	2	6	7	29	21	8	96
Loss %	50	94.8	45.0	94.7	50.0	56.3	+81.0	51.2	78.4	60.2

TABLE 12

SURVIVAL OF CATCHES (IN YEARS) OF *SARCOPHILUS HARRISI* AT GRANVILLE, 1969-70.

Year of Capture	Survival (in years)						
	0	1	2	3	4	5	6
1970	11	7	3	8	9	4	0
1969	11	2	1	1	1	0	0
1968	18	8	1	0	0	0	0
1967	30	6	15	3	1	0	0
1966	39	8	2	7	1	1	0

TABLE 13

MORTALITY AND SURVIVAL FOR EACH AGE GROUP OF *SARCOPHILUS HARRISI* AT GRANVILLE. The mortality has been calculated for each age group over the period 1966-74. Expressed as percentages of the survivors of the preceding group.

Age	Total population		Male		Female	
	M	S	M	S	M	S
1.5-2.5	38.8%	61.2%	16.7	83.3	47.8	52.2
2.5-3.5	26.3	73.7	20.0	80.0	40.0	60.0
3.5-4.5	28.6	71.4	33.3	66.6	42.9	57.1
4.5-5.5	40.0	60.0	37.5	62.5	50.0	50.0
5.5-6.5	83.6	16.6	60.0	40.0	100.0	0
6.5-7.5	100.0	0	100.0	0		

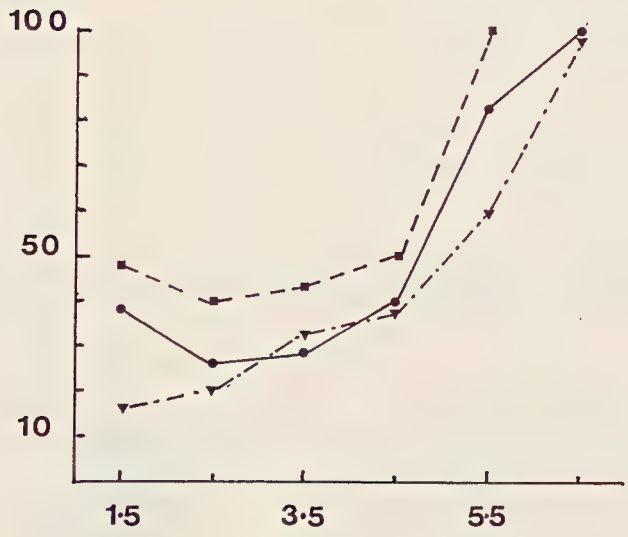

FIG. 11. - Percentage mortality of the age classes of *Sarcophilus*, Granville, 1966-74. Solid line - total population; squares - females; triangles - males. The mortality of the total population is not the mean of that of both sexes because a number of individuals were not sexed at capture.

SURVIVAL AND MORTALITY

The data used in the construction of figs 5-10 were reorganized (tables 12 and 13, fig. 11) to permit the construction of a survivor curve for the populations.

The survival for each group was calculated (table 13). In this table the age groups were calculated from age/weights of known animals and the survival of these groups was derived from marked devils. The curve indicates that there is a heavy early life mortality up to 2.5 years in the female population, and the males suffer a lower mortality rate than the females. The sex ratio changes noted above result from this differential mortality. The female devils disappear from the population before the males.

The low juvenile male mortality rate is unusual in a natural population where the mortality curve usually follows the pattern seen in the female population. This latter type of curve is usually associated with species having a large number of young produced by each female per annum (Seber 1973), a situation which cannot be applied to *Sarcophilus*.

NUMBERS

The population numbers in the area were calculated using four methods - Petersen Index, Modified Petersen Index, Manly-Parr Method (Seber 1973) and Hayne's Graphical Method (Hayne 1949). The estimates so obtained were all close to the observed population at the time (table 14) and no method offered any greater accuracy than another.

In the table, the observed number of devils (1) is the number of individuals caught the preceding November and which are assumed still to be living in the area.

The juvenile recruitment is taken from table 11, mortality was calculated from later records. There is a close correspondence between the calculated population and the observed population and the Petersen Index estimates based upon the trapping results gave very similar population estimates.

The number of devils captured at Granville decreased in 1969 and reached a minimum in 1970 but increased again to reach its maximum in 1974.

The population of devils found in each pair of years was compared for significance (table 15), three pairs of years being found to be highly significantly different at 0.1% level of confidence, namely 1968-1969; 1969-1970; and 1972-1973. Other less significant changes in population numbers were found in 1967-1968 and 1974-1975.

TABLE 14

POPULATION NUMBERS OF *SARCOPHILUS HARRISI* AT GRANVILLE, 1967-75.

Year	Observed Population (1)	Juvenile Recruitment	Immigration	Mortality	Calculated Population	Observed Population (2)	Petersen Index
1967	40	10	7	11	46	45	64
1968	45	2	7	6	48	23	21
1969	23	11	16	9	41	59	63
1970	59	2	11	58	14	20	20
1971	20	6	19	11	34	34	35
1972	34	7	17	22	36	39	46
1973	39	29	36	17	87	92	77
1974	92	21	21	45	89	106	100
1975	106	8	8	15	107	69	138

The Observed Population (1) is that found in November of the previous year; juvenile recruitment is the number of pouch young of the preceding year plus immigrant young (if any); immigration is the number of unmarked adults found in the area; mortality - animals never again trapped; calculated population is the sum of Columns 1-4; Observed Population (2) is the number of individuals caught in that year.

BIOMASS

The biomass of devils at Granville was calculated for each year (fig. 13). An increase in the number of devils corresponded to an equivalent increase in biomass except in 1971 when the biomass increase was less than might be expected and this may be attributed to the small number of devils of less than 7kg in the population (fig. 7).

The nutritional requirements of *Sarcophilus* are not known but assuming that the nutritional requirements of a dog of 6.8kg to be equivalent to that of a devil of the same weight, its requirements would be 0.43kg wet wt. of meat/day (following the Nutritional Research Council recommendations (1974)). Two Hereford cows die each month on the property and are left to the devils and assuming each beast to weight 500 kg of

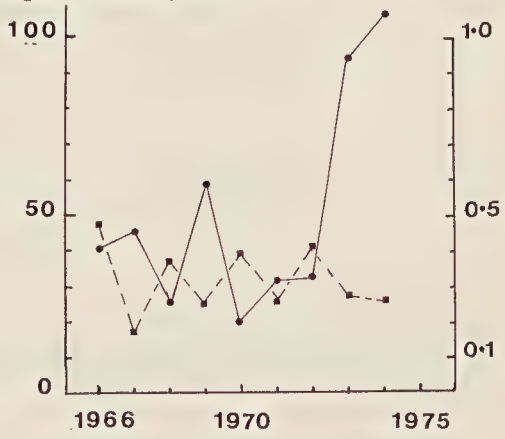

FIG. 12. - Numbers of *Sarcophilus* population at Granville in relation to the mortality, 1966-74.

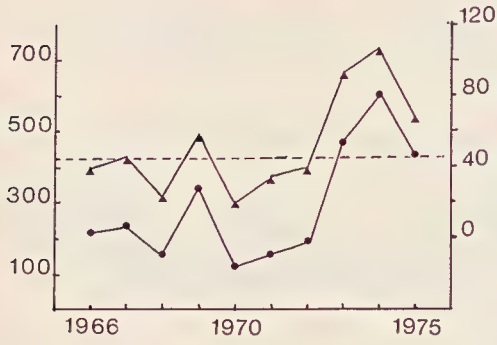

FIG. 13. - Biomass and numbers of *Sarcophilus* at Granville, 1966-75. Triangles indicate the numbers. Biomass (abscissa) in kilograms. Dotted line is the annual sustainable biomass of devils which can be maintained by cattle losses.

which 12% is bone and 40kg is digesta, the weight of available material is 400kg. Thus 24 Herefords/annum will support 415.92kg of devils/annum.

The population of devils in seven of the ten study years was at or below this level (fig. 13) so that it can be concluded that the population can be sustained at about 44 animals feeding on cattle losses alone, apart from other food sources such as carcases from game control operations, natural deaths of wild species and other foods. The use of food sources from agricultural activities can sustain a *Sarcophilus* population at Granville without total dependence on natural food resources or, alternatively, can maintain a population above that which would be sustained by normal food resources.

TABLE 15

CHI-SQUARE ANALYSIS OF PAIRED YEARS OF THE POPULATION OF *SARCOPHILUS HARRISI* AT GRANVILLE HARBOUR, 1966-75.

	Observed Population	Expected Population	χ^2	Significance
1966	40			
		42.5	0.29	N.S.
1967	45			
		34	7.12	++
1968	23			
		41	15.8	+++
1969	59			
		39.5	22.7	+++
1970	20			
		27	3.63	N.S.
1971	34			
		36.5	0.34	N.S.
1972	39			
		65.5	21.44	+++
1973	92			
		99	0.99	N.S.
1974	106			
		87.5	7.82	++
1975	69			

It is assumed that the expected population is the mean of each pair. N.S. - not significant; ++ - significant at 1% level of confidence; +++ - significant at 0.1% level of confidence.

DISCUSSION

The movements of devils around the property were found to be confined to several well defined trails with certain parts of the Farm being more heavily used than others. Adventitious food sources such as dead cattle serve as temporary attractions in any

region, but nevertheless certain overall activity patterns could be identified.

The decline in the number of captures on Round Hill in 1970 was most remarkable, only three of the trap sites yielding any animals during that year. Nevertheless the catching index for the Farms was approximately the same as usual, indicating that the devils were still in the general area and the field records showed that the emphasis of activity had shifted to the Dead Heifer Paddock-Pig Farm area. Sheep used to be kept on the Round Hill and were gradually removed in 1969-71. It has been found from experience elsewhere, that devils collect around sheep paddocks presumably attracted by the likelihood of obtaining food from dead or cast sheep and the withdrawal of sheep from Round Hill may well be the cause of the decline in devil numbers in that area.

The movement of devils to the Dead Heifer Pig-Farm area probably is also associated with the availability of food since numbers of *Wallabia* and *Thylogale* are shot around the edges of these paddocks as a game control operation, and this area is central to other paddocks in which shooting takes place. Also, the area is on the direct route via Duck Creek to Top Farm.

The distribution of devils on the Farm probably is related to potential and actual sources of food and the trails used by them are the most direct routes between these places. Devils favour cover whenever possible and move along certain well defined trails, traps set on these tracks nearly always make good catches although adjoining sites rarely make a capture.

It is clear that there often is a very considerable annual change in the population structure, this change usually appearing in animals other than immatures, namely other than by recruitment of pouch young. These animals may be expected to come from two possible sources, namely by immigration of new animals from the surrounding country or by a return of previously marked animals into the study area. The latter occurred in 1973 and 1974 when a high proportion of the 1970 cohort were retrapped after not having been caught in 1971 and 1972. The Farm offers attractive habitat for devils due to the ready availability of food from the game control operations as well as from deaths of agricultural stock so that animals will tend to remain in the area once they have entered it and emigration is unusual.

The survival of each catch follows a common pattern, a high percentage of each year's catch disappearing during the year subsequent to initial capture. This pattern was not followed by the 1970 cohort as the majority of this group were recaptured in 1973 and 1974, with strong survival in 1975.

The composition of each year's catch also follows similar patterns, most of the animals being new animals of the year, either by juvenile recruitments or by immigration. However, 1974 was unusual in that there were a large number of 1973 survivors in that cohort. Although there was a high percentage of 1970 survivors, these comprised only a small number of the large total catch.

The population in 1975 showed very unusual features in that there were a number of animals caught as juveniles in 1974, weight 5 4 kg, were recaptured when their weight fell into the same size class. These animals were adult by that time but this was not shown by a weight gain. Further, some adults of 1974 or earlier, were recaptured weighing less than in 1975. It can be speculated that food shortage led to this situation, but there was no field evidence that this was in fact so.

The annual population weight structure varies considerably from year to year, but generally shows dominance by one of the adult size groups, except in 1966 and 1973 when immatures formed the largest group. Recruitment into the population from pouch young was low in all years except in 1973 and 1974. This is especially true of the

males when 1973 was the only year in which there was a large male recruitment from pouch young. This would perhaps suggest that the male population is largely maintained by a low annual rate reinforced by sporadic good recruitment.

The largest size group, 9kg, was, with the exception of 1967 when one female reached that weight, entirely composed of males. The largest proportion of the male population was composed of animals of greater than 7.75kg, although exceptions occurred in 1973 and 1974. These large males were always more numerous than females of the same weight groups. It has been shown (Buchmann and Guiler 1977), that social dominance is largely controlled by the size of the individual devil, so it follows that there are considerable behavioural and social implications in the dominance of the population by large males. Intraspecific competition occurs around food, and in the natural situation at Granville the food is concentrated into restricted sites around carcases so that the larger and aggressive males will be able to deny or restrict access by other devils. Recruitment of juvenile males into the population is usually low, 1973 being the only exception. The sex ratio of pouch young is 1:0.95 and that of juveniles is 1:1.67 suggesting a differential mortality between these two age groups and this may well be due to the social and numerical dominance of large males having a greater effect upon male than female recruitment.

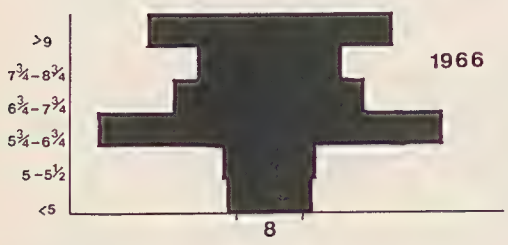

FIG. 14. - Population structure for *Sarcophilus harrisi* at Cape Portland, north-eastern Tasmania, 1966.

Dominance of the population by large males is not confined to the Granville area as Cape Portland showed the same composition in 1966 (fig. 14). However, in a population at Auburn where annual cropping takes place as a control measure, there are only small numbers of large males and juvenile recruitment is correspondingly high, annual samples showing a high proportion of males of 5.75kg.

The recruitment from pouch young is low with losses up to 94.7% being recorded, but in 1972-73 the recruitment was 81% greater than the numbers of pouch young recorded in the area. This probably resulted from an immigration of young juveniles into the area following successful breeding in the adjoining country.

The mortality curves shows a differential mortality rate between the sexes, females having a higher mortality in the 1.5-2.5 year animals, whereas the males have a lower rate than the females throughout life. The sex ratio of the population shows the effects of this differential mortality, the sex ratio of the pouch young slightly favouring males, whereas the females dominate the young stages followed by a strong dominance by the males in the adults. It has been suggested above that the poor male recruitment is a result of social interactions at feeding sites leading to a female dominance of the 0.5-1.5 year group. Any uniform mortality upon this group must cause higher female death rates.

It has been shown that *Sarcophilus* does not gain most of its food by predation (Buchmann and Guiler, 1976, and in preparation) and most of its food is obtained from carrion. Comparative data for eutherian species of similar habitats are not available although Kruuk (1972) showed that mortality in the spotted hyaena in Ngorongoro is high (1.8) up to 3 years and then low for a further 3 years and then remaining at 1.0 for the rest of life. However, he found that recruitment was much greater than in the devil. Similar mortality was found in the black bear where 13% die between 0.5 and 1.5 years which is low but this is followed by high mortality (Jonkel and McCowan 1971). By contrast the mortality in *Sarcophilus* at Granville is very high in the 0-1.5 year

groups and recruitment is based largely upon immigration from the surrounding areas, probably on account of the attractiveness of the Farm rather than to any major surplus of animals in the surrounding country.

The population at Granville from 1966-70 differed significantly from year to year, then the number of animals increased sharply and highly significantly in 1973 and this population level was maintained in 1974 due largely to high immigration but assisted by a high survival of earlier year catches combined with a low mortality rate. No apparent reason can be found for this increase, the amount of food being no greater than that of previous years nor was there less predation upon the devils. The number of devils at Granville in 1975 was significantly less than those in the previous year. The field evidence such as footprints, and scats, supported this, but there was ample similar evidence that numbers of devils were at Top Farm, attracted there by an intense game control shooting programme. These animals may be caught in a later year.

The Granville area in 1966 at the start of this work had small numbers of devils in comparison with other parts of Tasmania (Guiler 1970a), and the population throughout Tasmania has increased steadily since 1958 so that they now are numerous in many places where they were unknown 20 years ago. One of the features of this population explosion was the short time in which it occurred, taking about five years to spread over the State. There is no evidence in this field study of any contemporaneous increase in numbers at Granville, rather to the contrary in 1968, 1970-72, and it was not until 1973 that the population expanded rapidly. Many other pastoral properties in Tasmania still have many more devils than are found at Granville, e.g. Auburn where 250 were taken in one year (1974) as a control measure. From this, it would seem as if the Granville population has been slow to react to the factor or factors causing the population explosion over much of the rest of Tasmania. On the other hand, the Granville devils may form a separate population from those in the other parts of the State.

The Granville devils are smaller and weigh less than those at Cape Portland, but this does not necessarily establish a geographical race or separate population, being more likely to be a result of the nutritional status of the individuals, those at Cape Portland living on mixed sheep-cattle pastoral area and being very much better fed than the Granville animals. Examination of a series of skulls from each area failed to reveal any major differences to suggest separate races. Nevertheless, the Granville animals are geographically isolated from those living in the farming area of the State, the Pieman River to the North and Macquarie Harbour to the South and the rainforests to the East forming boundaries through which little if any exchange of animals can take place. With the exception of Granville and Top Farm, there is no agriculture in all of the Pieman-Macquarie Harbour area so that food availability in the area has not altered due to increased farming since 1976. Rather to the contrary as sheep farming has ceased in the area during this study. The ability of cattle losses to support a devil population without recourse to natural food emphasises the fact that *Sarcophilus* has profited from white man's presence in Tasmania.

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APPENDIX 1.

Numbers of *Sarcophilus* by sex captured at Granville 1965-74, together with the number of traps and the calculated catch/1000 traps.

	1965-8					1969					1970					1971				
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Slaughterhouse	11	7	8	159	50	0	1	1	5	200	0	1	1	6	166	0	0	0	0	0
Top Farm	5	7	12	63	190	0	0	0	0	-										
Top Farm Track	12	10	22	95	231	3	4	7	99	70										
Acre	1	2	3	12	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Round Hill	27	30	57	372	153	18	13	31	209	148	6	4	10	105	95	5	1	6	18	333
Fairfields	5	10	15	198	75	1	2	3	43	69	1	1	2	35	57	1	2	3	45	67
Harbour Paddock	0	1	1	21	48	0	0	0	9	0	0	0	0	0	0	0	2	2	14	142
Main Road	1	3	4	94	42	0	0	0	5	0	0	0	0	0	0	0	1	1	24	41
Barn	4	1	5	44	113	0	0	0	0	0	0	0	0	0	0	2	0	2	12	166
Harrison's No.1	5	5	10	75	133	1	3	4	118	34	1	1	2	16	125	0	0	0	0	0
Harrison's No.2	0	0	0	8	0	0	0	0	0	0	1	0	1	15	66	0	0	0	0	0
Nicholas' Paddock	1	1	2	13	153	6	5	11	60	183	0	0	0	9	0	0	0	0	0	0
Harrison's Back Pockets	0	1	1	5	200	4	9	13	75	173	4	2	6	27	222	1	1	2	26	77
Duck Creek Track	0	1	1	10	100	2	4	6	101	59	0	0	0	0	0	0	0	0	12	
The Farm	4	2	6	54	111	0	2	2	6	333	0	0	0	0	0	0	0	0	12	0
Granville Town	2	0	2	14	142	1	1	2	6	332	0	0	0	0	0	0	0	0	0	0
Zeehan Track	0	5	5	40	125	2	2	4	13	307	0	0	0	0	0	6	10	16	54	296
Dead Heifer	0	0	0	0	0	2	2	4	18	222	3	4	7	20	350	3	3	6	27	222
Pig Farm	0	0	0	0	0	0	2	2	11	91	0	0	0	0	0	0	0	0	0	0

A = number of males; B = number of females; C = Total; D = number of traps; E = catch/1000 traps.

APPENDIX 1 (continued)

Numbers of *Sarcophilus* by sex captured at Granville 1965-74, together with the number of traps and the calculated catch/1000 traps.

	1972					1973					May 1974					Nov. 1974				
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Slaughterhouse	0	1	1	3	333	0	0	0	6	0	0	0	0	0	0	2	1	3	13	153
Top Farm																0	0	0	0	0
Top Farm Track						3	2	5	49	102	0	0	0	0	0	0	0	0	0	0
Acre	1	0	1	6	166	6	5	11	29	379	11	2	13	17	764	4	1	5	24	208
Round Hill	1	0	1	6	285	1	1	2	18	111	0	0	0	0	0	0	0	0	0	0
Fairfields	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Harbour Paddock	0	0	0	0	0	1	0	1	6	166	0	0	0	0	0	1	0	1	12	83
Main Road	0	0	0	0	0	10	1	11	77	143	0	0	0	0	0	0	0	0	0	0
Barn	0	1	1	4	250											0	0	0	0	0
Harrison's No.1	0	1	1	3	333	4	2	6	28	214	2	1	3	20	150	1	0	1	18	56
Harrison's No.2	0	0	0	0	0	2	2	4	36	111	0	0	0	0	0	3	4	7	44	159
Nicholas' Paddock	6	2	8	44	181	0	0	0	0	0	16	7	23	44	552	3	5	8	45	177
Harrison's Back Pockets	1	0	1	35	28	9	5	14	65	215	9	6	15	61	245	4	6	10	72	139
Duck Creek Track	3	3	6	20	214	0	0	0	0	0	3	3	6	26	230	2	12	14	36	389
The Farm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Granville Town	0	0	0	0	0	7	13	20	44	455	0	0	0	0	0	2	2	4	16	250
Zeehan Track	3	4	7	112	62	44	24	68	187	363	28	15	43	116	370	16	10	26	168	155
Dead Heifer	5	4	9	33	272	12	9	21	91	230	20	9	29	49	591	6	8	14	82	171
Pig Farm	5	3	8	21	380	8	9	17	90	189	17	14	31	54	574	20	13	33	104	317

A = number of males; B = number of females; C = Total; D = number of traps; E = catch/1000 traps.

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WHALE STRANDINGS IN TASMANIA SINCE 1945 WITH NOTES ON SOME SEAL REPORTS

The Clive Lord Memorial Lecture
to the Royal Society of Tasmania
October 4th, 1977

by Eric R. Guiler
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(with eight tables and one text figure)

ABSTRACT

Five species are added to the last published list of Tasmanian Cetacea together with details of 73 hitherto unrecorded strandings of previously reported species. Details are given of mass strandings of sperm and pilot whales and a table of pigmy right whale strandings is brought up to date. One species is reported from Tasmania for the first time.

INTRODUCTION

I never had the privilege of knowing Clive Lord but very soon after my arrival in Tasmania in 1947 I felt that I should know him and perhaps even meet him soon because his name kept occurring in so many conversations relating not only to natural history but also to other more general matters. Now, his name still appears in the literature and is still referred to in conversations over a wide range of zoological topics so that it is abundantly clear that his labours were not in vain and as long as natural history is studied his work will survive.

An important aspect of Lord's work was his interest in many facets of natural history and also in the history of Tasmania and of its aboriginal peoples. Reference to the Papers and Proceedings of the time shows this interest very clearly in the titles of the papers which he submitted to the journal. In those days it was possible to follow a wide spread of interests, indeed one had to do so as there were so many fascinating facts to be recorded and so few people to do it. The increase in specialization that has occurred in recent years means that workers of such breadth are becoming very rare. However, it was in the Vertebrates that Clive Lord found most of his interests and this was shown in a series of papers with another great Tasmanian, H.H. Scott of Launceston, and resulted finally in the production of the *Vertebrate Animals of Tasmania*.

One of the groups in which Lord was interested was the whales and he published a series of papers on the Cetacea in our Proceedings between 1918 and 1928. These were in collaboration with H.H. Scott whose son still continues a family interest in these animals. Thus, it is not entirely without relevance that I have chosen the Cetacea as the topic for this Memorial Lecture.

I chose 1945 as a starting point since I assumed that Lord and Scott would have reported any important strandings prior to that date. Davies (1963) published the details of our whale fauna but since that date a substantial number of records of strandings both of species new to Tasmania and of new localities have come to light. Some of these records give some useful information on the biology of some of our whales. It now seems appropriate to bring our records up to date from the scattered literature in which the original information was published as well as gathering in reports from previously untapped sources.

Illustrations are not given for each species as this was done by Davies and, in

any case, the identification of many whales by external characters is very difficult and cranial examination is essential in most of the more obscure species.

Unless otherwise acknowledged, all strandings are reported here for the first time and no strandings have been included after 30/9/1977.

Suborder ODONTOCOETI

The Toothed Whales

These whales are easily identified by the presence of one or more pairs of teeth in each jaw and by the absence of whalebone.

Family PHYSETERIDAE

This is a small family of sperm whales, only one species of the three in the Family occurring positively in Tasmania. Another species may well occur here but has not yet been recorded whilst the last species is tropical in affinities.

Physeter catodon L.
Sperm Whale

A large whale reaching 18 m. with the head square in lateral view, mouth small and triangular in shape with a long aperture; fifty to sixty large teeth in lower jaw only; no dorsal fin but some irregular humps on the posterior back appear above water when swimming; blowhole on top left of head; purplish brown colour with a white mouth.

Distribution: Oceanic throughout the world; usually found in herds, migrates to temperate seas in summer; formed part of the basis of the Tasmanian whaling industry and still is one of our most commonly stranded whales.

Tasmanian Records: Perkins Is., 10/2/1911, 36 males, one female (? 38 and all male - see Scott, 1942a); Stanley, 8/3/1936, male, 14.6 m; Wivenhoe Beach, Burnie, 9/2/1940 (Scott, 1942a); Stanley, ?/?/1958, 9.2 m (*Mercury* 10/5/1958); Yellow Bluff, ?/?/1960; W. of South Croppies Pt. 25/3/1963, alive when first seen (R. Munro, *pers. comm.*); W. of Tomahawk Point, 27/5/1963, male, 13.9 m; S. of Grassy, King Is., ?/12/1967, skull only (J. Gratton Wilson, *pers. comm.*); Burnie, 6/1/1967, "51 feet" (*Mercury*, 7/1/1967); ?/?/?, N. of Granville Harbour mandible seen at next report; N. of Granville Harbour, May 1966, female, 10.5 m; Cape Grim, ?/?/? mandible seen at next report; Cape Grim, late winter 1969, female, 10.5 m with calf, 2 m; the size of the claf suggests that it probably was aborted; Cape Grim, 22/9/1970, 58 whales, details below; Stanley, 28/3/1971, 32 whales, 25-45 feet (*Mercury*, 29/3/1971); Strahan, 10/6/1971, one animal (*Mercury*, 12/6/1971); Three Hummocks Is. 12/1974, one animal; West Beach, N. Tasmania 4-5/10/1975, two females (per. R.H. Green), data in Launceston Mus.

The Cape Grim stranding: A mixed herd of 58 whales were stranded on a rocky platform in a reef-locked shallow bay between Cape Grim and two off-lying islets, The Doughboys. At the site were the remains of a previously stranded cow and calf together with a mandible of an even earlier stranding. Most of the Tasmanian strandings occur on sandy beaches and this site is not usual, being of a rocky substratum, although the Granville strandings also took place off a rocky coast. The sex ratio was 10 males: 48 females (B. Ritchie, *pers. comm.*), my count based on 52 remaining whales was 11:41. The sizes of the whales is shown on table 1. The sex/size composition of the herd suggest that it possibly was a harem although the number of calves suggests that it probably was a nursery. There were no males larger than 14.02 m. A number of females had enlarged or lactating mammary glands although the significance of this was hard to determine as putrefaction was well under way. Five such females were identified with certainty although there may have been more.

TABLE 1

Length (m) and sex of *Physeter catodon* stranded at Cape Grim, Tasmania, September, 1970.

Males:	3.04,	6.49,	7.35,	7.62,	8.23,	9.15,	9.17,	10.57,	11.13,	12.95
Females:	3.50,	6.04,	7.62,	7.80,	8.35,	8.50,	8.53,	8.78,	9.12,	9.19,
	9.19,	9.33,	9.39,	9.67,	9.73,	9.86,	9.93,	9.97,	10.06,	10.09,
	10.20,	10.25,	10.29,	10.33,	10.36,	10.44,	10.52,	10.57,	10.85,	10.87,
	10.97,	10.97,	11.00,	11.05,	11.05,	11.12,	11.22,	12.04,	12.57	

The sex composition of the Cape Grim school resembles that of the stranding at Gisborne reported by Robson & van Bree (1971) who found 13 males and 46 females. The size distribution was similar in both strandings.

The size of the males indicates that there were no large sexually mature animals in the school, accepting Best's (1969) figure of 13.72 - 14.01 m as the size at which males reach maturity.

The presence of a very small calf of less than 4 m length of each sex strongly suggests that these animals were aborted during the death of the mother as Best's (1970) growth curves suggest a birth length of about 4m for this species. Best (1968) estimated the age of maturity of females as 8.23 m and this would place 35 of the Cape Grim whales as mature with four immature and two not examined. Clarke (1956) estimated the size of weaning as 6.7 m and this indicates that all but four of the immature whales were weaned.

The Cape Grim stranding site yielded meagre information on three separate strandings so it is apparent that this area presents some hazard for Sperm Whales. It was shown by Bannister (1968) that *Physeter* moves parallel to the coast off Western Australia and several authors, notably Best in South Africa, Gaskin in New Zealand, Nishiwaki in Japan, Bannister in Western Australia and Matthews in South Georgia, have noted that the population increases in on-shore areas in the summer. From this it would seem that the Cape Grim stranding was of a school which was following an earlier than usual on-shore movement. However, Gaskin (1972) noted that in New Zealand these whales avoided shallow water areas except for sick or stranded specimens. Best (1969) found that the 300 fathom (approx 550 m) contour limited the shallow water penetration of *Physeter* off the west coast of South Africa.

The 300 fathom contour lies about 180 kilometres off-shore at Cape Grim so it would seem as if these whales were unusually close inshore and probably had become entrapped in the shoals and reefs of the partially enclosed bay. Sperm whales, being a deep water species would lack the experience to handle these conditions.

The date of the stranding may be correlated with a movement along the coast but it was too early to be part of the summer movements. However, it was not possible to determine whether the whales were moving either northwards or southwards or whether they were seeking to enter Bass Strait, which has a maximum depth less than 300 fathoms. There is no doubt that *Physeter* does enter the Strait as five of the 11 Tasmanian strandings have occurred within the Strait, though it may be argued that the reason these whales have stranded there is because they entered the Strait. Clearly, the shallow waters do not deter the whales from entering the area whether they subsequently leave it or not but there is no evidence that herds pass through the Strait as part of their normal movement pattern. The topography of the bay at Cape Grim is such that southbound animals would tend to be more confused than northbound since the latter would tend to be directed offshore by the Doughboy Islands at the southern end of the bay.

Kogia breviceps (Blainville)
Pygmy Sperm Whale

The head is bulbous and, as in the sperm whale, has the small triangular mouth ventrally placed, with 18-20 curved teeth in the lower jaw only; teeth of the upper jaw buried in the gum; head one fifth to one sixth of total length which is about 4 metres; the small dorsal fin with a very concave rear edge; flippers broad and placed forward on the body; blackish-grey above, whitish below.

Distribution: South Africa (Sclater, 1901); Western Australia (Hale, 1963); South Australia (Hale, 1939; Aitken, 1971); New South Wales (Wall, 1851); probably Queensland (Hale, 1963); New Zealand (Gaskin, 1968).

Tasmanian Records: One mandible of unknown origin in Tasmanian Museum (Lord & Scott, 1924); Pearson (1936) gives Tasmania as a record.

Remarks: A common species in the Port Elizabeth district of South Africa (Ross *pers. comm.*) but never positively recorded from Tasmania. From its distribution it must surely strand here sometime but can easily be confused with pilot whales by casual observers (see Hale, 1931).

Two specimens of *Kogia* were recorded by Hale (1959) from South Australia and were assigned to this species but later these were found to belong to a very similar but smaller species, *K. simus* (Handley, 1966; Aitken, 1971). This species can be separated from *breviceps* by the possession of one pair of maxillary teeth and other cranial features listed by Aitken. This species may also occur in Tasmania.

Family ZIPHIIDAE
The Beaked Whales

The beaked whales are little known and for this reason have provided us not only with the most interesting strandings but also present most intriguing problems of identification as the species frequently can only be recognized by detailed examination of the skull. These whales possess teeth, the number ranging from one pair in the lower jaw to many in each jaw but in general the species recorded here have few teeth. The common name is derived from the beak-like snout. They do not have a tail notch and there is a prominent V-shaped groove under the throat. McCann (1962a) provided a key to the identification of this Family. Little is known of the factors controlling the distribution of the ziphiids although Gaskin (1971) suggested that in New Zealand they appear to be concentrated in waters between 11.6°C and 16.9°C.

Ziphius cavirostris Cuvier
Cuvier's Beaked Whale; Goose-Beaked Whale

Length to nine metres; flippers small; dorsal fin small and placed well back on body; distance from tip of jaw to blowhole is one ninth of total length; eye twice as far from the tip of snout as from inner angle of mouth; two conical teeth at end of lower jaw in males only which also have a forehead bulge.

Distribution: Not yet recorded from the Arctic or Antarctic but generally distributed elsewhere in the northern and southern hemispheres (Mitchell, 1975b); known from South Australia (Aitken, 1971), New South Wales (Iredale & Troughton, 1934), New Zealand (Gaskin, 1972).

Tasmanian Records: Port Arthur, c. 1868 (Scott and Lord, 1920b); Preservation Is. (Scott and Lord, 1920b); Coles Bay - dried skull found on Jan/1950 (Davies, 1963); Cloudy Bay, Jan/1953, male about six m, skull total length 0.935 m (A. & R. Hammond,

pers. comm); Five miles N.E. of Henty River - dried skull recovered by G. Davis 5/9/1960; Pieman Heads, c. 1972; skull 0.93 m total length recovered in 1974 by Mr. G. Addison; Seymour July 1974, female six m, skull in Tasmanian Museum; Friendly Beaches Jan/1977 male (W. Boyles *pers. comm.*). Only the Seymour specimen was examined as a whole specimen although decomposed. The Friendly Beaches whale was partially buried when examined by W. Boyles. Measurements of the Seymour animal were:- snout - anterior angle of jaw 0.28 m; angle of jaw - orbit 0.295 m; orbit length 30 mm; snout - anterior of blowhole 0.656 m.

Remarks: This species does not commonly strand in Tasmania although it is the most common of the Family. All the Tasmanian strandings are of individuals but the whale probably is not solitary in habits as a mass stranding was reported from the Antilles by van Bree & Kristensen (1974) and Gaskin (1971) saw a herd of 30-35 whales at sea some of which were possibly of this species. It is taken commercially in Japan (Nikiwashi & Ogura, 1972; Mitchell, 1975a) and provided Omura (1972) with material for an osteological study and also providing other information.

Mesoplodon densirostris (Blainville)
Blainville's Beaked Whale; Dense-beaked Whale

General ziphiid form but small in size, not longer than 4.4 m (McCann, 1963); flukes and flippers of moderate length; two massive teeth in lower jaw in the male only but only the tip of tooth projects above the gum; the teeth form a prominent lateral process on the lower jaw; fins placed well forwards, low on body; as with all other members of this genus, identification of the female is difficult. Black colour with grey ventral surface.

Distribution: Most strandings of this species are from tropical or warm temperate waters in the Pacific, Atlantic and Indian Oceans. Nineteen strandings of *M. densirostris* are recorded by Besharse (1971), the only other Australian records being those of Longman (1926) from Yeppoon, Queensland, 1926; Lord Howe Is. (Krefft, 1870).

Tasmanian Records: Marrawah, 31/7/1964, adult male (Guiler, 1966).

Remarks: Most strandings have occurred on coasts with either warm water or warm currents and Moore (1958) believed that this species was of tropical or subtropical habitat. McCann (1964) suggested that the Carribean is their breeding ground. The Marrawah specimen was the only animal to strand on the eastern side of an oceanic mass.

Bruyns (1968) sighted some beaked whales at sea off the Azores and tentatively assigned them to this species.

Mesoplodon hectori (Gray)
Hector's Beaked Whale

Externals not described as this is a very little known species. The Tasmanian specimen was decomposed and had been attacked after death by sharks with much damage to flukes and fins and leaving the intestines protruding and the dorsal musculature in tatters.

Distribution: South Africa; Tasmania; New Zealand, Falkland Is.

Tasmanian Records: East Cove, Adventure Bay, female, 12/3/1966 (Guiler, 1967).

Remarks: This is one of the rarest of our whales as only six specimens are known, New Zealand and South Africa having two strandings each. The Tasmanian specimen, the skull of which was described in detail by Moore (1972) is the only known mature

specimen and measured about 3.5 m.

Fraser (1950) suggested that this species is circumpolar in distribution and Guiler (1967) thought that it was rare north of 45°S. latitude. Ross's (1970) discovery of two young specimens from 34°S. in South Africa does not support this latter view and sheds some doubt upon Fraser's suggestion but clearly much has to be learned about this species.

McCann (1962b) concluded that this species represented the young of *Berardius arnuxi* but Moore (1968) strongly disagreed with this view and his conclusion that *M. hectori* is a separate species has been followed here.

Mesoplodon bowdoini Andrews
Andrew's Beaked Whale

Slightly slimmer in shape that the usual rather squat *Mesoplodon* form; characteristic large subtriangular teeth, only one pair, situated in the middle of the lower jaw with the teeth not erupting through the gum in the female.

Distribution: South Pacific (Moore, 1963a, 1966).

Tasmanian Records: Marion Bay, date unknown, skull in Tasmanian Museum (Guiler, 1967).

Remarks: This is another little known whale as only eight other specimens appear to have been recorded, five from New Zealand, one from Campbell Island, one from Western Australia (Gaskin, 1972) and one from Victoria (Dixon, 1970).

Mesoplodon layardi (Gray)
Strap-toothed Whale; Layard's Beaked Whale

Larger than most of the genus being up to 5.5 m in the male and 4.5 m in the female (the Japanese records, however, suggest that the female is larger than the male); dark-purplish brown above with some white patches (Gaskin, 1972); bronze-green dorsally (Hale, 1959); males with one pair of large flat tusk-like teeth in the lower jaws which pass outside the rostrum and curl over towards the midline.

Distribution: Nearly world-wide (Moore, 1963b); cosmopolitan (Mitchell, 1975b); frequently stranded in New Zealand (Gaskin, 1972); Victoria (Warneke, 1963); South Australia, 11 specimens (Hale, 1939).

Tasmanian Records: Recherche Bay, 1922 (Flynn, 1922); Recherche Bay, winter of 1925 (Scott & Lord, 1927); Slopen Is. Feb/1966 (Guiler, 1967).

Remarks: Although this whale is well known from New Zealand and South Australian strandings it is not a common species in Tasmania. It may perhaps be significant that all our strandings have taken place on the far south coast of the island.

The species is well known from overseas material, especially Japanese. It has been shown that this species possesses a condylus tertius, a feature which also occurs in *M. densirostris*, *M. grayi* and *M. bidens* (Robson & van Bree, 1972).

Mesoplodon grayi von Haast
Scamperdown Whale; Gray's Beaked Whale

Almost 6 m long; teeth present but inconspicuous, situated towards the end of the mandibular symphysis and larger in the male than the female.

Distribution: South Africa (Barnard, 1954); South Australia (Hale, 1939); Victoria (Brazenor, 1933); New Zealand (Gaskin, 1968); Patagonia (Oliver, 1922).

Tasmanian Records: Eaglehawk Neck 21/4/1946; Cloudy Bay, Bruni Is. Jan/1968; unlabelled complete skeleton in Tasmanian Museum (Guiler, 1969).

Remarks: This is the most common ziphiid on New Zealand shores, no less than 25 being recorded by Gaskin (1968), but it is not well known from Tasmania. Osteomyelitis was evident in the skulls from both Eaglehawk Neck and Cloudy Bay and may have been the cause of death in the latter specimen.

Berardius arnuxi Duvernoy
Large Beaked Whale; Arnux's Whale

Beak very stubby but large in contrast to other ziphiids; two pairs of teeth at the end of the lower jaw in the male; the teeth are embedded in the gum in the female; this is a large species reaching almost 9 m in length; blackish brown above with greyish ventral surface.

Distribution: South Africa (McLachlan *et al.*, 1966); South Australia (Hale, 1962); New Zealand (Gaskin, 1972); Falkland Is. (Norman and Fraser, 1937); Antarctic (Taylor, 1957).

Tasmanian Records: Visits Tasmanian waters (Lord & Scott, 1924); North of Port Davey in Jan/1977. The skull was very weathered with the sutures opened and loose. The supraoccipital was missing as were much of the pterygoid processes as well as the posterolateral parts of the maxillae. However, such measurements and ratios as could be obtained fell clearly within the parameters for this species as described by Hale (1962).

The skull was drawn to my attention by Mrs. B. Tracey of Kingston High School and was presented by the School to the Tasmanian Museum.

Little is known of this species. Fifteen strandings are known in New Zealand and this record would appear to be about the twentieth known. The only other Australian record is from Port Lorne, South Australia in December, 1935. The current report is the first positive Tasmanian record for the species.

Hyperoodon planifrons Flower
Bottlenosed Whale

Bulbous forehead, dorsal fin placed well back; large size, more than 9 metres; one pair of teeth at the tip of the lower jaw in the male; beak short, forehead bulbous and prominent; darkish brown-black, whitish ventrally.

Distribution: South Australia (Hale, 1931); Western Australia (Flower, 1882); New Zealand (Waite, 1913); Falkland Islands Dependencies (Fraser, 1945).

Tasmanian Records: Nil. Visits Tasmanian seas but only at intervals (Lord & Scott, 1924).

Tasmacetus shepherdi Oliver
Shepherd's Beaked Whale

Differs from all other ziphiids in that it has small teeth in both jaws with the terminal pair well developed; length about 9 m; black dorsally, grey or grey-yellow flanks, white underneath (Gaskin, 1972).

Distribution: New Zealand (five specimens, Gaskin, 1972); Argentina (Mead & Payne, 1975); Falkland Is. (Smith, 1965).

Tasmanian Records: Nil. May well turn up some time.

Family GLOBICEPHALIDAE
The Large Dolphins

Orcinus orca (L.)
Killer Whale

A large toothed whale up to 9 m in length with a characteristic high shark-like dorsal fin; flippers rounded and paddle shaped; many strong teeth in both jaws; black with prominent white patches on the side and head, belly white; the dorsal fin of old males becomes very large and tends to flop over sideways and the flippers enlarge and reach one fifth of the body length.

Distribution: Cosmopolitan.

Tasmanian Records: Not infrequently seen around our coasts but strandings are unusual; Adventure Bay, 1868 (Lord & Scott, 1924) appears to be the only record.

Remarks: This whale apparently does not strand frequently anywhere as a total of only six strandings have been reported from New Zealand although no less than 38 sightings were reported in 1963-64.

Pseudorca crassidens (Owen)
False Killer Whale

Length about 6 m with a large dorsal fin which is not nearly as large as in the killer whale; bulging forehead (compare with *Globicephala* spp.); teeth of circular cross-section in both jaws; flippers neither paddle-shaped nor elongated; entirely black in colour.

Distribution: Cosmopolitan (Gaskin, 1972).

Tasmanian Records: Adventure Bay (Scott and Lord, 1920); Stanley, 30/5/1936, more than 100 individuals (Pearson, 1936); Stanley, 28/7/1937 (Scott, 1942a); Eaglehawk Neck, Dec./1946 (Tasmanian Museum); Fanny's Bay, Piper River, Oct./1957, one animal; Seal Bay, King Is., Sept./1958, 50 individuals (both records Scott & Green, 1975); Friendly Beaches June/1963 and Nov./1964 (latter stranding was of 50+ individuals); Perkins Island 18/6/1974, 43 individuals; Fortescue Bay Feb./1977 - skull recovered; from a stranding about June, 1976 (B. Knight *pers. comm.*); skull of unknown origin, Cygnet Area School.

Remarks: This species comes ashore infrequently but often does so in large schools. Details of the Stanley strandings were given by Scott & Green (1975). The Friendly Beaches strandings did not come to my notice until 1966 when no useful measurements could be made, but skulls were recovered.

It is to be noted that most of the strandings of this species occur in the winter or spring and summer-autumn strandings have not been reported. This may be fortuitous but is supported to some extent by New Zealand strandings most of which have occurred from March-July.

A stranding at Bicheno, 16/12/1964, may have been of this species (*Mercury*, 10/12/1964) and further strandings described as "killer whales" but more probably of this

species occurred at Black River, June/1974 (*Mercury*, 17/6/1974); West Point, Marrawah, Feb./1972 (*Mercury*, 1/3/1972); N.E. Flinders Is. Aug./1974, 50 individuals "25-30 feet long" (*Mercury*, 31/8/1964).

Globicephala macrorhyncha Gray
Tropical Pilot Whale

Differs from the more common *G. melaena* in the proportion of the fin which is about one sixth of the body length; there are cranial differences as well; black in colour.

Distribution: Tropic Seas.

Tasmanian Records: Green's Beach, 9/5/1973, female (Scott & Green, 1975).

Remarks: A tropical species found here only once but may be more frequent and confused with the pilot whale. Scott and Green give measurements of the only Tasmanian specimen.

Globicephala melaena (Traill)
Southern Pilot Whale; Blackfish

Prominent dorsal fin with a long base almost twice as long as high; length, 6-8 m; prominent bulging forehead; flippers long and narrow about one fifth of body length; teeth in both jaws but only at the anterior part compared with *Pseudorca* where they extend the full length of the jaw; frequently with a white-greyish colour patch below throat extending as a line down belly; white saddle posterior to dorsal fin also a patch posterior to eye but melanics are frequent and can be confused with *G. macrorhyncha*.

Distribution: Cosmopolitan. Davies (1960) suggested that the northern and southern populations have been separated since the Pleistocene by *G. macrorhyncha*.

Tasmanian Records: Stanley, 14/10/1935, 300 individuals, 80 males and 114 females in 194 individuals (Pearson, 1936), measurements of these whales given by Scott (1942); Marion Bay, 22/12/1955, 200 individuals; Macquarie Harbour Mar./1959 (Davies, 1963); Marion Bay, 1956, 20 individuals; Ralphs Bay, Aug./1957, one individual; Howrah, 24/11/1957, one female; Seven Mile Beach, Jan./1966 - specimen in Tasmanian Museum; Pardoe Beach 26/3/1967, 150 animals, (*Mercury*, 27/3/1967); Seymour, 23/8/1968, one female; Boomer Beach, Maria Is., 14/1/1973, 33 individuals, mostly females but one male, 4.2 m (A. Hewer *pers. comm.*); Cox's Bight, Jan./1975, one animal (I. McKendrick, *pers. comm.*); Two Mile Beach, Dunalley, 18-9/2/1975, 200 individuals; Two Mile Beach, Dunalley, 28/2/1975, two individuals; Seymour, June/1975, female, melanic, photograph of skull identified by P.H. van Bree; Ocean Beach, Strahan, 18-19/3/1977, five animals. Further strandings believed to be of this species occurred at Cloudy Bay, Nov./1917, 120-130 individuals (letter in *Mercury* whale file). The Seymour Female - measurements, total length 5.46 m; length of flipper 1.08; length of posterior edge of flipper 0.815; width of flukes 0.53; snout to anterior edge of dorsal fin 1.51; length of dorsal fin 0.68; height of dorsal fin 0.28; snout to anterior edge of orbit 0.44; snout to anterior edge of blowhole 0.47. The Two Mile Beach Stranding - Sex ratio 39:54. The mean total length of 39 males was 5.055 m and of 54 females was 4.087 m. The largest male was 6.2 m and the largest female measured 5.55 m and details of the measurements are given in Table 2, and the measurements of a new born, probably aborted, young also are shown in Table 2.

A remarkable feature of this stranding was the apparent rapidity with which decay set in. The whales were examined on the third day after stranding and almost without exception the abdominal wall had ruptured and the intestine was extruded and in many cases had burst. Photographs by Scott (1942b) showed no similar signs of decay two

TABLE 2

Measurements (in m.) of *Globicephala melaena*, Two Mile Beach, Tasmania 18-19/2/1975. The sample size is shown in brackets after each measurement. The dimensions of a small male, probably aborted, are given in the right hand column.

		Male	Female	Young Male
1.	Total length	5.054 (39)	4.087 (54)	1.87
2.	Snout - anterior orbit	0.417 (6)	0.396 (9)	0.185
3.	- anterior of blowhole	0.43 (6)	0.40 (9)	0.17
4.	- anterior border of flipper	0.748 (6)	0.678 (9)	0.305
5.	- axilla	0.985 (6)	0.887 (9)	0.42
6.	- vent	2.74 (3)	2.384 (8)	1.06
7.	- anterior of dorsal fin	1.613 (6)	1.302 (8)	0.71
8.	- posterior of dorsal fin	2.278 (4)	2.094 (8)	1.01
9.	Height of dorsal fin	0.40 (6)	0.299 (8)	0.14
10.	Length of dorsal fin	0.565 (4)	0.586 (8)	0.30
11.	Length of anterior border of flipper	1.133 (6)	0.861 (9)	0.385
12.	Length of posterior border of flipper	0.847 (6)	0.633 (9)	0.27
13.	Maximum width of flipper	0.288 (5)	0.224 (9)	0.11
14.	Width of flukes	1.055 (6)	0.841 (8)	0.35
	Ratio 1/14	4.79	4.85	
	1/9	12.63	13.68	
	1/6	1.84	1.71	
	1/11	4.46	4.74	
	1/12	5.97	6.45	
	1/10	8.94	6.97	
	1/8	2.21	1.95	

days after stranding. Experience with other species showed that rupture may not take place for a longer period, if at all. Mr. T. Dunbabin who reported the stranding assured me that the whales were alive on stranding only three days before.

Remarks: The flipper measurements given by Pearson (1936) for the Stanley strandings would place these animals as *G. macrorhyncha* (16.9% of the total body length). However the detailed measurements given by Scott (1942b) show that the flipper length falls within the range for *G. melaena*. None of the parameters measured by Scott showed any marked sexual dimorphism with the exception of the ratio of the length of the dorsal fin to the total length of the animal which is different in the two sexes. This dimorphism was also noted in the animals from Two Mile Beach. It was noted that the length of the dorsal fin in males was very variable and this may accentuate the possible dimorphism.

Some taxonomic dispute exists as to the relationship of this species. The arguments were summarised by Gaskin (1972) who followed Davies (1960) in recognising only one species of Southern Pilot Whale.

The Strahan strandings of March, 1977 occurred after a period of rough weather. The five animals were spread over about 8 km of beach. Only three animals were examined, two females and one male. Also stranded at the same time was an *Arctocephalus* bull and a female *Tursiops*.

This whale frequently strands on our coasts in both small numbers and large schools and is one of our most common species.

Family DELPHINIDAE
Dolphins

Tursiops truncatus (Montagu)
Bottle-nosed Delphin

Beak blunt and sharply defined from forehead; 20-22 pairs of teeth in each jaw; dorsal fin prominent and large; length to 4.5 m; dark-grey above (grey-green, Gaskin, 1972), shading to white ventrally; white streak anterior to eye.

Distribution: Widely distributed in temperate seas. South Australia (Aitken, 1971); Victoria (Wakefield, 1967); New Zealand (Gaskin, 1972).

Tasmanian Records: Tamar River; King Is.; N.W. Coast (Scott & Lord, 1920a); Lisdillon 25/9/1920 - skull in Tasmanian Museum; Stanley, 11/1/1939 (Scott, 1942a); Ralph's Bay, May/1964 - one animal stranded but swam off at high water; Maria Is., Booming Beach, Jan./1973; Ocean Beach Strahan, 18-19/3/1977 five animals, including two female, one male, largest female measured 3.02 m; North-west Bay, 20/7/1977 10 animals.

Remarks: Although a common species it does not strand as often as might be expected. The behaviour of the Ralph's Bay stranding in swimming away on the next tide suggests that these whales are more able to cope with this situation than many others. Only nine records are known from New Zealand.

Tursiops aduncus (Ehrenberg)
Macgillivray's Bottle-nosed Dolphin

Very difficult to distinguish from *T. tursio* (see Ross, 1977). Recorded from Tasmania by Iredale and Troughton (1934) but this needs confirmation.

Lissodelphis peroni (Lacépède)
Right Whale Dolphin

No dorsal fin or hump on back; black dorsally with a vivid white belly fairly sharply demarcated from the black; beak short, 43 pairs of teeth in each jaw.

Distribution: Temperate and Sub-antarctic waters of the South Pacific and Tasman Sea; south of Australia (Gaskin, 1972).

Tasmanian Records: Specimen from Tasmania in Royal College of Surgeons' Museum, London. Date and locality unknown (Davies, 1963).

Remarks: This species has been seen at sea off Tasmania but apparently is oceanic and rarely strands.

Lagenorhynchus cruciger (D'Orbigny)
Southern White-sided Dolphin

Beak very short, almost absent; dorsal fin with a long base and a strongly curved posterior surface; prominent black and white patterns of variable shape on flanks with the black back not clearly set off from the white belly; black circumorbital patch; a small species less than 2 m in length.

Distribution: Oceanic in high latitudes (Gaskin, 1972).

Tasmanian Records: One skull in Tasmanian Museum (Pearson, 1936).

Remarks: The colour patterns for this species are so variable that about six other species have been erected to cater for them. However, modern thought is that they are only varieties.

Delphinus delphis L.
Common Dolphin

Slender and graceful with a long beak, tapering forehead; many teeth in both jaws; deep purple brown dorsally and yellow-white ventrally with a pattern of fine stripes round the eye and the base of the beak; dark line from the base of the jaw to the flipper; post-mortem colour changes may leave the belly pink in colour.

Distribution: Cosmopolitan (Norman & Fraser, 1937); South Australia (Aitken, 1971); Victoria (Wakefield, 1967).

Tasmanian Records: Tasmania (Scott & Lord, 1921; Pearson, 1936); Spring Bay, Dec./1955; Eaglehawk Neck, Dec./1944 and 3/6/1967; Seven Mile Beach 15/5/1952; Slopen Main 1/5/1967; South Arm 1/2/1967 - five individuals (all records from the Tasmanian Museum); D'Entrecasteaux Channel - Dec./1975 - about 109 individuals.

Remarks: The only large stranding of this species in Tasmania is that in 1975 when about 100 animals stranded over about 30 km of shore from Adam's Bay to Simpson's Point on the Channel side of Bruny Island. Other strandings have been of small numbers of dolphins.

The D'Entrecasteaux Channel Stranding - It is believed that this stranding occurred from a very large school of dolphins which passed southwards through the Channel early in December. Isolated individuals washed ashore in other places as far away as Howden but it is thought that these animals had floated away from their original point of stranding. The original school was observed by the author and Mr. T.L. Sward when it was south of Zuidpool Rock with animals constantly breaking water in an area about 1.5 km x 8 km. There were other species besides common dolphins in the school as noted from colour patterns but we were not close enough to determine their identity.

The mean length of 15 females was 1.6193 m and that of 12 males was 1.1483 m. Detailed measurements of two specimens of either sex are set out in Table 3. A total of 69 animals were examined from the total of 109 and of these 30 were male and 39 female.

One dead animal had *Zostera* in the stomach according to Mr. G. Davis who was on the site of stranding.

This species appears in North-west Bay, D'Entrecasteaux Channel around June each year and disappears again in December according to Mr. R.M. Nicholl who lives in the area.

Other Dolphins

There are six species of dolphins which are not yet recorded from Tasmania but are known to occur in Tasmanian waters or else have appeared on nearby coasts. These are *Cephalorhynchus hectori*, *C. commersoni*, *Stenella euphrosyne*, *S. caerulo-alba*, *Grampus griseus* and *Feresa intermedia*. Some of these may well have been observed but confused with *Delphinus* or *Globicephala*. A "spotted dolphin" was reported from Barnes' Bay by Mr. R. Haigh on 13/2/1976 and may have been *Stenella dubia*.

TABLE 3

Measurements (in m) of two specimens of each sex of *Delphinus delphis*, Great Bay, Tasmania.

	Female		Male	
Total Length	2.09	1.71	2.14	2.20
Snout to eye	0.31	0.29	0.335	0.33
to blowhole	0.34	0.31	0.35	0.35
to anterior dorsal fin	0.90	0.76	0.90	0.93
Length of dorsal fin	0.33	0.26	0.32	0.35
Posterior of dorsal fin to tail notch	0.86	0.695	0.92	0.92
Width of flukes	0.37	0.30	0.33	0.34
Snout to anterior of flipper	0.51	0.43	0.51	0.52
Width of flipper (axilla)	0.10	0.09	0.095	0.10
Posterior of flipper to vent	0.73	0.63	0.75	0.79
Length of vent	0.03	0.04	0.06	0.05
Vent to tail notch	0.57	0.465	0.75	0.76
Length of anterior border of flipper	0.33	0.26	0.23	0.33
posterior border of flipper	0.23	0.19	0.18	0.245
Teeth - upper jaw	42	43	45	40
lower jaw	42	46	46	44

Suborder MYSTACOCETI
Whalebone Whales
The Right Whales

Eubalaena australis (Desmoulins)
Southern Right Whale

No dorsal fin; the bonnet - a roughened area on the head - is characteristic; mouth strongly arched; flippers short and rounded; length about 15-18 m; colour black.

Distribution: Formerly widespread, now greatly reduced in range and numbers.

Tasmanian Records: Used to form the basis of the Tasmanian whaling industry. Seen at sea off Cape Sorell May/1959 (Davies, 1963); Prion Bay 17/4/1974 (*Mercury*, 19/4/1974); S.W. Cape, 18/9/1973 female and calf (A. Cuthbertson *pers. comm.*).

Remarks: A whale with calf that appeared at Blackmans Bay for several years in the 1960's may have been of this species. Although once so common in the River Derwent that it was dangerous to row across the river this species nowadays is rarely seen. It does not strand frequently probably because it often swims in shallow water just outside the surf line and so is used to these conditions.

The Prion Bay specimen was photographed from the air by Mr. V. Reid who reported that the whale had been attacked and driven ashore by a large shark as he saw the incident from his plane.

Copies of the photographs of the S.W. Cape animals clearly are of this species. The female was estimated to be 12-15 m long and was accompanied by her calf in about 12 m of water. The sea conditions had been rough and the sea was described as milky. At one stage the calf nestled alongside the boat and could only be dislodged with difficulty.

This species was heavily fished in the early days and its slow speed made it easy

to catch and this, combined with its rich oil made it a desirable haul. Sexual maturity in the female is reached at 13-14 m. Although not fished since the early 1920's, recovery has been slow and probably only a few thousand still exist.

Caperea marginata (Gray)
Pygmy Right Whale

A small baleen whale up to 5.5 m without throat grooves, differing from the right whale in having no dorsal fin; inside of mouth is vivid white; whalebone is creamish-ivory coloured with a prominent black border; dorsal surface black, whitish ventrally.

Distribution: South Africa, Western Australia, South Australia, Tasmania, New Zealand, South America. All strandings from these areas were reviewed by Davies and Guiler (1957), and this list is brought up to date in Table 4.

TABLE 4

Details of strandings of *Caperea marginata* following upon the list published by Davies & Builer (1957).

36	New Zealand	Site unknown	1887-89	van Bree *pers. comm.*	Vienna Museum
37	Tasmania	Rebecca Creek	Nov./1953	Lyne, *pers. comm.*	Univ. of Tas.
38		Simpsons Bay	9/1/1959	M. 4.8 m.	See text.
39		Pirates Bay	Nov./1950	F. Guiler, 1961	
40		Pirates Bay	June/1961	F.	
41		Simpsons Bay	Jan./1961	M. 4.5 m.	
42		Elliott Cove	1962	?(per W. Denniss).	
43		Big Taylor Bay	27/4/1966	F.	
44		Big Taylor Bay	11/1/1968	F.	Tas. Museum.
45		Tinderbox	20/9/1966	?(*Mercury*, 20/9/1966)	
		Near Dennes Point	Dec./1966	?(per W. Denniss).	
		Pt. Hibbs	13/1/1967	F. 4.3 m. per W. Denniss.	
		Pirates Bay	Dec./1974	?(per R. Rish)	
		Chinamans Bay	Mar./1976		
		Cloudy Bay	Mar./1976	M. 6.1 m.	
	South Australia	Port Lincoln	Before 1948	Juvenile, Aitken, 1971.	
		Port Lincoln	16/8/1960	Aitken, 1971.	
	Victoria	Portland	1946	Wakefield, 1967	
	South Africa	False Bay	27/2/1963	2.9 m, Ross *et al.*, 1975.	
		Port Elizabeth	18/12/1965	2.98 m, Ross *et al.*, 1975.	P.E. Museum
		Mossel Bay	Dec./1967	Baleen only. Ross *et al.*, 1975.	
	Falkland Is.			Hamilton, 1952.	
	South Atlantic	32°56'S;12°42'E	29/11/1970	M. 5.47 m, Ivashin *et al.*, 1972.	
		33°40'S;00°56'E	4/12/1970	F. 6.21 m, Ivashin *et al.*, 1972.	

In addition a number of sightings have been made of living animals as follows:

South Africa	False Bay	Feb./1965	Ross *et al.*, 1975.
	False Bay	Feb./1965	Ross *et al.*, 1975.
	Plettenberg Bay	Dec./1967	Ross *et al.*, 1975.
	False Bay	Jan.orFeb./1968	Ross *et al.*, 1975.
South Atlantic	32°56'S;12°42'E	29/11/1970	Ivashin *et al.*, 1971.
	Crozet Is.	23/2/1970	Budlyenko *et al.*, 1973.

Remarks: Specimen No.38 a damaged skull, was presented to me by Dr. A.G. Lyne who found it on a beach in a weatherworn condition from a stranding of unknown date.

Specimen No.39 was a whale which was captured by Messrs. W. and F. Denniss while seine-netting for bait in 2-3 m of water in Simpsons Bay. The whale was totally butchered for bait but J.L. Davies and I were able to positively identify it as a *Caperea*. As far as can be ascertained Mr. Denniss and his son were the first to observe this species alive and at sea. Abstracts of our interview with them read.... "whale sighted in Simpsons Bay at 01.00 hrs on night of 8-9/1/1959, a mild calm moonless night. The whale was sighted in about 3 m of water with the back and fin above water when swimming. Spouts were twin divergent forwards directed at about 3-5 minute intervals. The whale was speared continually and swam at about 8 km/hr only showing a violent reaction when the tail was touched. The whale was forced ashore and died about 0.600 hrs probably due to heavy blood loss (seen subsequently in the tissues). The underside was grey in colour. Post-mortem examination revealed a small intestinal tapeworm and the stomach contained only an amorphous yellow paste. A Leishmann smear did not show any blood parasites. Ring-like dorsal markings with one side of the ring more deeply incised than the other were noted and these are not incompatible with Utrecht's (1959) suggestion that scars of this nature are made by lampreys."

The rate of swimming and the anteriorly directed twin spouts resemble those of *Eubalaena*. The fact that the animal was seen on a moonless night may account for the scarcity of coastal sightings relative to the number of strandings.

The strandings of *Caperea* per month are shown on fig. 1 and it is clear that with more data than was available to Davies & Guiler (1957) these whales are present in Tasmanian waters nearly all the year round except in April-May and August. The absence of strandings in these months may be due to chance rather than to any absence of the whales from our coasts. There appear to be three peaks of abundance, namely December-January, March and June, but this may only be a result of chance in strandings. The strandings in New Zealand and South Africa show some evidence of seasonal occurrence, expecially in South Africa but the sample size is very small and there is no apparent reason why the species should not occur there all year round as in Tasmania.

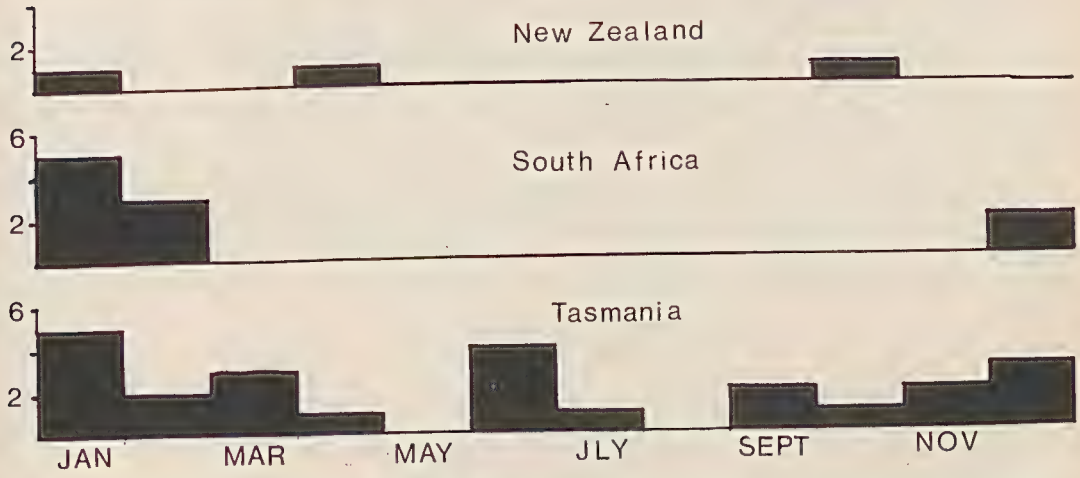

FIG. 1 - Strandings of *Caperea marginata* each month in three southern continents. All known dates of strandings are shown as listed in this paper and Davies & Guiler (1957).

Little is known of breeding in *Caperea*, the only evidence being one pregnant female stranded at Eaglehawk Neck in November 1950 (Guiler, 1961). This date is within the breeding season for balaenids.

The sightings by Russian whalers of *Caperea* in deep water are of interest as these are the first records of the use of deep water by this species. The highly typical flattened, strong ribs of *Caperea* are not characteristic of the Cetacea and, together with the shallow water areas in which strandings usually occur, led Davies & Guiler (1957) to postulate that this species spent some time in shallow water, even perhaps resting on the bottom for feeding. However, it is clear from Ivashin *et al.* (1972) that although in deep waters the whales were feeding at the surface and did not dive to depths of more than 2-3 m and remained submerged for only 2-3 minutes. The Russians reported that dissection of *Caperea* revealed that the whale had a small heart and this suggests a shallow diving species.

The beautiful underwater photographs of *Caperea* (Ross *et al*, 1975) give a very much slimmer outline than that hitherto described from stranded specimens.

Family BALAENOPTERIDAE

Balaenoptera acutorostrata Lacepede
Piked or Minke Whale

Throat grooves, about 50 in number, extended about halfway to the vent; whalebone short, yellowish, upper jaw not arched; black above, whitish below including underside of flukes.

Distribution: Oceanic, cosmopolitan. Western Australia (Chittleborough, 1953); Victoria (Wakefield, 1963).

Tasmanian Records: Lewisham (new born young), 7/6/1957 (Davies & Guiler, 1958); Tomahawk, Aug./1972, female, 5.48 m (per. G. Parr); Fortescue Bay 6/8/1973, male 3.65 m.

Remarks: The Tomahawk specimen was identified from a photograph taken by Mr. G. Parr who estimated the length at about 5.5m.

The Fortescue whale was in an advanced state of decay with the lower jaw broken off. It had probably been dead at least a month when examined. The birth length of a minke whale is about 3.0 metres and this would indicate that the Fortescue specimen was just recently born as was the Lewisham whale. The Tomahawk specimen is about half grown.

It probably is significant that the strandings occurred during the winter period and that two of these were very young animals indicating that calving takes place in or close to Tasmanian waters. Wakefield (1967) reported a 2.1 m long whale from Victoria stranded in October, 1946.

Balaenoptera musculus (L.)
Blue Whale

Baleen black, dorsal fin very small but flippers relatively large being about one seventh total length; throat grooves extend to beyond posterior end of flipper but not to vent; length to 30 m; greyish blue all over with paler ventral patches.

Distribution: Oceanic. Victoria (Wakefield, 1967; Brazenor, 1950).

Tasmanian Records: Although once an important commercial species these whales have

not stranded very often in Tasmania and the only record, possibly of this species is from New Norfolk in the River Derwent, May 1825 (*Hobart Town Gazette*, 6/5/1825). A large jaw bone seen in 1965 protruding from a sandhill at the Thornton River, West Coast, may well be of this species.

Balaenoptera physalis (L.)
Southern Finback; Finner

Throat grooves extending halfway from flipper to vent, i.e. to navel; dorsal fin prominent, baleen yellowish white with grey band; 20-30 m; dorsal surface light grey often mottled with white, ventral surface white including underside of flukes and flippers; lower jaw with white on right side, left side grey.

Distribution: Oceanic, all oceans.

Tasmanian Records: Pitt Water, July/1965. Female, about 18 m.

Remarks: The only Tasmanian record was a most unfortunate individual which passed through the narrows at Dodges Ferry and ended up stranded in shallow water near Green Island where it died and was subsequently towed out to sea.

Balaenoptera borealis Lesson
Sei Whale

Balaenoptera edeni Anderson
Bryde's Whale

Neither of these rorquals have been recorded from Tasmania although they probably occur in our waters. The latter species was found in Victoria by Dixon (1970).

Megaptera novaeangliae (Borowski)
Humpback Whale

Readily identified by the enormous flippers with a number of rounded protruberances; dorsal fin small and followed by a number of dorsal irregularities; baleen black; 12-15 m; blackish colour merging to greyish; frequently has white circular skin scars; often with barnacles attached to flippers, skin and jaws.

Distribution: All oceans, used to be commercially important.

Tasmanian Records: Bass Strait (Lord & Scott, 1924); Circular Head 4/10/1936 (Scott, 1942a); Marion Bay Oct./1953; Fortescue Bay Jan./1958 - three seen at sea; Darlington, Maria Is. 25-26/4/1969 cow and calf seen at sea.

Remarks: Although once common this species has not stranded very often. In the days of abundance these whales migrated up and down the Tasmanian coast and were often sighted at sea.

Suborder PINNIPEDIA

The Seals

Superfamily PHOCOIDEA
The Earless Seals

Hydrurga leptonyx (Blainville)
Leopard Seal

Head large with prominent crest; teeth markedly carnivorous and bright white against red gums; spotted grey, yellow white body; nostrils form long prominent slits; about 3.5 m.

Distribution: Mainly Antarctic and Subantarctic seas and islands but moves north during the winter. Western Australia (Serventy, 1948); Victoria (Wakefield, 1963); New South Wales (Troughton, 1951).

Tasmanian Records: Tasmania (Davies, 1963); Ralphs Bay Apr./1968 and 8-10/9/1968; Adventure Bay 2/9/1968 (?same animal); Triabunna 26/9/1974; Margate 4/10/1975; Adventure Bay 11/10/1976, female 2.59 m; Fortescue Bay Apr./1977 mandible recovered (C. Ellis).

Remarks: This is a very agile species and must be treated with caution. It probably is more numerous on our coasts than the absence of early records would suggest.

Lobodon carcinophagus (Hombron & Jacquinot)
Crab-eater Seal

Dark grey shading to light grey on flanks with red-brown circles and irregular patches; teeth very characteristic having lobes on them for filtering their euphausiid food from the water.

Distribution: Pack ice but may wander north.

Tasmanian Record: Ralphs Bay Sept./1945 (Davies, 1963).

Mirounga leonina (L)
Southern Elephant Seal

A large beast, males up to 6 m and weighing 3,500 kg but the females are smaller, about 4 m and 700 kg; skin frequently heavily wrinkled, grey or dark brown, often scarred round the neck; male has an inflatable proboscis; uses forelimbs in terrestrial locomotion.

Distribution: Subantarctic islands.

Tasmanian Records: Formerly widespread and used to be the basis of the King Is. seal industry. A female gave birth to a pup in Strahan Nov./1958 (Davies, 1963); Eaglehawk Neck, Fev./1948, young male; Ralphs Bay, Aug./1961; north of Granville Harbour, 1967, remains found in November; Flinders Is. Mar./1957; Adventure Bay, July/1973; Cloudy Bay 29/2/1975; Parsons Bay, Nubeena 2/3/1976; Meredith River, 17/7/1977.

Superfamily OTARIOIDEA
The Eared Seals

Arctocephalus doriferus (Wood-Jones)
Southern Fur Seal

Brownish yellow but dark brown when wet; uses tail flippers for terrestrial locomotion; males have a mane.

Distribution: S.E. Australia.

Tasmanian Records: This is our common seal and is to be seen all round our coasts and

is the species commonly found dead on the shores. The species breeds on Tasmanian islands and hauls out at a number of places. Detailed lists of strandings are rather pointless for such a common species.

Neophoca cinerea (Péron & Lesueur)
South Australian Sea Lion

Ears small but visible externally; large size; dark chocolate brown when wet but light brown when dry, like *A. doriferus* this species uses the hind limbs turned forwards in land movement.

Distribution: South Australia.

Tasmanian Records: King Island, pre 1900; Beach East of Cape Barren, Cape Barren Island, 22/2/1973 (both records by courtesy of Mr. P. Andrews, Tasmanian Museum).

Remarks: These are the first records of this species for Tasmania and it may well have been here before but can easily be confused with the fur seal, from which it can be identified by the absence of underfur and by the arrangement of the nails on the flippers.

DISCUSSION

Reference to table 5 will show that certain places have more frequent strandings of Cetacea than others, the greatest number being reported from Stanley and Eaglehawk Neck (seven each), followed by Marion Bay and Cloudy Bay, Friendly Beaches and Seymour, Cape Grim and Granville Harbour. However, some of these places are more liable to have mass strandings than others, notably Stanley, Marion Bay and Friendly Beaches. However, perhaps not too much reliance should be placed upon the frequency of mass relative to single strandings as the former are a conspicuous event and liable to attract attention whereas the single stranding may well pass unnoticed. It is apparent that the N.W. end of Tasmania has more mass strandings than elsewhere and the Marion Bay and Friendly Beaches areas have most in the rest of the State.

TABLE 5

Places in Tasmania from which more than one stranding of Cetacea have occurred, 1945-77. m - indicates a mass stranding.

East Coast		South Coast		North Coast	
Seymour	3	Adventure Bay	3	Burnie	2
Friendly Beaches	1 + 2m	Recherche Bay	2	Tomahawk	2
Maria Is.	2 + 1m	Slopen Is.	2		
Marion Bay	2 + 2m	Cloudy Bay	4	Northwest Coast	
Dunalley	1 + 1m	Seven Mile Beach	2		
Eaglehawk Neck	7	Ralphs Bay	3	Stanley	9 + 3m
Fortescue Bay	3	Big Taylor Bay	2	Cape Grim	2 + 1m
		Simpsons Bay	2 + 1m		

The Eaglehawk Neck area has a large number of strandings but three of these were provided by the pygmy right whale and each of these events took place at the south-eastern end of the beach near the jetty.

Each of the above areas differs from the other in its general features so that it is not possible to seek common topographical features which may in part account for the strandings. Stanley is the most likely place for strandings if we accept that shoal waters with shallow channels are the most dangerous for whales. Eaglehawk Neck

on the other hand offers deep water offshore in the bay with no shoals or other obstructions to whales. The common stranding site at the jetty does not experience heavy surf and strandings there cannot be understood other than resulting from illness or navigational error.

Marion Bay and Friendly Beaches both are surf beaches and have temporary sand bars set up in the surf area. The Friendly Beaches, site of many strandings, have a rocky reef offshore which could well cause navigational problems for whales.

The number of strandings each month shows that more strandings of whales can be expected to occur (46.3% of the annual total) during the summer period December-March than in the remaining 8 months of the year (table 6). Such data as are available for seals show a tendency towards winter-spring strandings.

TABLE 6
STRANDING OF WHALES & SEALS IN TASMANIA

All known records of strandings of whales and seals in Tasmania arranged by major groups and by months. A mass stranding is treated as a single event. Only leopard and elephant seals are included in the seal records.

	Sperm Whale	Ziphiids	False Killer	Pilot Whale	Dolphins	Whales	Pygmy Right Whale	Others	Sub-Tot.	Seals	Total
Jan.	1	3	0	2	2	0	5	1	14	0	14
Feb.	3	0	0	1	1	0	2	0	7	2	9
Mar.	3	1	1	3	2	0	4	0	14	2	16
Apr.	0	1	0	0	0	1	3	1	6	1	7
May	2	0	2	0	3	1	0	1	9	0	9
June	1	0	1	2	0	0	4	1	9	0	9
July	0	2	1	0	0	0	1	0	5	2	7
Aug.	0	0	1	2	0	0	0	2	5	1	6
Sept.	0	0	1	0	1	1	2	0	5	2	7
Oct.	2	0	1	1	0	0	1	2	7	2	9
Nov.	0	0	1	2	0	0	2	0	5	1	6
Dec.	1	0	1	1	3	0	3	0	9	0	9
									95	13	108

Sperm whales may be expected to strand in the summer which might be expected from the migration patterns while False Killer Whales and *Globicephala* apparently are in our waters all year round. The ziphiids are absent from August to December and, apart from one isolated incident, dolphins have not been recorded from June-November. However, we have seen in the case of *Caperea marginata* that more data revealed that the species is present all year round and this may well turn out to be for other species.

AFFINITIES OF THE TASMANIAN CETACEA

The Tasmanian cetacea are derived from four sources (table 7) and two of the elements may be expected to occur here, namely the cosmopolitan and Austral Circumpolar species. However, two species have been found in Tasmania which were of tropical origin, namely *Globicephala macrorhyncha* and *Mesoplodon densirostris*. The former species is described as northern Australian by Mitchell (1975b), whilst *M. densirostris* has been previously recorded from Yeppoon near Rockhampton. Strays from the tropical Indo-Pacific areas thus can reach Tasmania and should be anticipated in the future.

The circumpolar species may penetrate from some distance into all the southern oceanic masses but records of many of them are scanty. Three of this group of whales

TABLE 7
AFFINITIES OF THE TASMANIAN CETACEA

Species recorded with an asterisk have not been positively recorded but may be expected to occur.

Cosmopolitan	Austral circumpolar	Tropical
Megaptera novaeangliae	*Mesoplodon hectori*	*Mesoplodon densirostris*
Balaenoptera acutorostrata	*bowdoini*	*Globicephala macrorhyncha*
Orcinus orca	*grayi*	
Pseudorca crassidens	*Berardius arnuxi*	
Physeter catodon	* *Hyperoodon planifrons*	
Globicephala melaena	* *Tasmacetus shepherdi*	
Delphis delphis	*Kogia breviceps*	
Mesoplodon layardi	*Caperea marginata*	
Tursiops truncatus	*Balaenoptera musculus*	
Ziphius cavirostris	*physalis*	

have never been found in Tasmania and a watch should be kept for *Kogia breviceps*, *Hyperoodon planifrons* and *Tasmacetus shepherdi*. All of these are odontocetes and the last two are ziphiids.

The Family Ziphiidae provides us with some of our most exciting whale collecting as some of the species which are likely to be found ashore here are very rare and are known by less than 20 specimens. We know little of their habits, movements or food and any stranding of a beaked whale is of importance.

The number of strandings per annum appears to have increased sharply since 1955 but this may not be the result of an increase in public interest in whales as a result of publicity (table 8). The paucity of reports from Lord's time I feel does show that not many whales came ashore during that period as his interest in the matter was such that he would have recorded their arrival. The early whaling days of the Colony brought an initial interest in whales and this lapsed until the work of Lord, together with Scott, renewed our awareness of these mammals and long may this continue.

TABLE 8
NUMBERS OF WHALE STRANDINGS IN TASMANIA, 1955-1977

A mass stranding is treated as a single stranding. Note that there appears to be a bimodal distribution in the frequency of strandings but this may not be of any significance.

1955	2	1960	3	1965	1	1970	1	1976	3
1956	1	1961	2	1966	7	1971	2	1977	5
1957	4	1962	1	1967	7	1973	4		
1958	1	1963	3	1968	4	1974	7		
1959	3	1964	5	1969	1	1975	5		

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STIPA L. IN TASMANIA - HISTORICAL NOTES:

TAXONOMIC CONTRIBUTIONS 1768-1968 AND

THE TYPE LOCALITY OF *STIPA FLAVESCENS* LABILL.

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(with two text-figures and two plates)

ABSTRACT

Short notes are given on the history of the study of *Stipa* L. in Australia with particular emphasis on the Tasmanian contribution. The type locality of the enigmatic *S. flavescens* Labill., is established as Robert's Hill, Bruny Island.

TAXONOMIC CONTRIBUTIONS 1768-1968

Introduction

Australia has a special significance in the history of the world's study of *Stipa* as some of the first species descriptions in the genus were based on Australian specimens collected by the earliest of the Antipodean explorers. Labillardière (1804) described *S. elegantissima* a West Australian species and *S. flavescens* from Tasmania, both of which he collected while accompanying Bruni D'Entrecasteaux on the expedition searching for the missing explorer La Perouse (Labilladière 1799). Robert Brown (1810, 1835) described five more Australian *Stipa* species, which were included in the plant collections he made between 1802-1805 while travelling with Matthew Flinders on board the *Investigator*.

Outside of Australia the Russian botanist Trinius (1831) was one of the earliest contributors to the world's literature on *Stipa* with his description of *S. ramosissima*, an Australian species. With Ruprecht in 1842 he published "Species Graminum Stipaceorum" which included two other *Stipa* species of Australian origin, *S. commutata* and *S. pubinodis*, the latter being Tasmanian. The German taxonomists Sprengel (1827) at Halle, Steudel (1854) at Stuttgart, and much later Pilger (1904) and Mez (1921) both at Berlin, working on herbarium collections which included Australian material, brought more order into the genus as then known. Work on the Australian *Stipa* flora after 1920 was concentrated at Kew (Hughes 1921, 1922; Hubbard 1925; Summerhayes and Hubbard 1927).

Within Australia, Bentham (1878) assisted by Baron von Mueller, and also Bailey (1902), Rodway (1903), and Black (1922) based the *Stipa* sections of their floras on the earlier works of Labilladière (1804), R. Brown (1810, 1835) and J.D. Hooker (1855-60).

D.K. Hughes, working on the type collections at the Herbarium, Royal Botanic Gardens, Kew, revised the Australian species of *Stipa* (1921, 1922), and enumerated 43 endemic species although greatly handicapped by the nature of the material. Most of the specimens in this collection had been gathered in autumn and winter, and were either overmature or immature. Some were incomplete, and in general there was insufficient variety of specimens to give a true picture of the range of living plants within each entity. Nevertheless Hughes' Revision was a most useful work and it provided the basis for subsequent investigations of the genus. Ewart (1931), Gardner (1952), Willis (1962), Burbidge (1966), and Burbidge and Gray (1970) have all made use of it

in compiling their floras.

The type material of the bulk of the Australian species is held at Kew. In addition to the generally poor quality of the specimens, the difficulty of obtaining this material for study in Australia has resulted in a considerable degree of confusion between species. A new revision which is urgently required is currently in progress (Dr J.W. Vickery *pers. comm.*). Relatively few type specimens are lodged in Australian Herbaria. They include those belonging to the species described in the various State Journals by Tate (1885, South Australian species), Reader (1897-1901, Victorian species), Black (1918, 1920, 1941, South Australian species), Vickery (1951, New South Wales species), Blake (1952, Queensland species), and Townrow (1970, Tasmanian species).

Consequent upon the accidents of history, and the routes travelled by the first Australian explorers, Tasmania features largely in the early accounts of *Stipa* species in Australia.

The early explorers 1768-1800

Joseph Banks and Daniel Solander accompanied Captain Cook on his first voyage to the Southern Hemisphere (1768-71), (Hooker 1859), and collected the very first Australian *Stipa* specimens in the vicinity of Botany Bay near Sydney. They knew nothing of the existence of Tasmania.

The first botanists to set foot in "Insula Van Diemen", as Tasmania was called, were David Nelson and William Anderson who accompanied Cook on his third voyage. They landed at Adventure Bay in January 1777, late in the growing season (Hooker 1859). *Stipa* occurs rarely in that vicinity at the present time, and predictably was not among their plant collections.

Jacques-Julien de Labilladière, who went in search of La Perouse with Bruni D'Entrecasteaux in the ship *La Recherche* (Labillardière 1799; Stafleu 1967a), visited Tasmania twice. He first landed at Storm Bay in late autumn on April 23rd 1792, and in the ensuing month collected mostly shrubs and small herbs. The return visit of the Expedition to Adventure Bay (January 22nd-March 1st 1793) was earlier in the season although still rather late for obtaining first class *Stipa* material. Labillardière then explored widely in the vicinity, collecting many plant specimens along the shores of the newly discovered channel between Bruny Island and the mainland (named D'Entrecasteaux in honour of his Captain). There is little doubt that the type material of *S. flavescens* Labill. was collected during that time, probably in the vicinity of Simpsons Pt. or Robert's Hill on North Bruny (see p.218). Labillardière's first set of plants (i.e. of best quality) was later acquired by P.B. Webb who in turn bequeathed his herbarium to the Grand Duke of Tuscany and the town of Florence. Most of these specimens are still at the herbarium (FI) (Stafleu, 1967b).

The Brown and Hooker period 1800-1890

Robert Brown came to Tasmania eleven years after Labillardière's short visits. Engaged as naturalist to Matthew Flinders on his voyage to New Holland in the *Investigator*, Brown arrived in Tasmania in January 1804 with the first British settlers in northern Tasmania. He collected plants, including the type material of *Stipa semibarbata*, near the mouth of the River Tamar around Port Dalrymple (George Town). During the later part of his nine months' visit, between February and September 1804, he collected specimens in southern Tasmania around Risdon Cove, along the River Derwent, and also on Table Mountain (Mount Wellington) which he found "uncommonly productive" of new species (Hooker 1859; Brown quoted in Stearn 1962). *Stipa* was not well represented among the 700 species he recorded for Tasmania in his PRODROMUS (Brown 1810, 1835). Of the eight *Stipa* species listed therein only *S. semibarbata* and *S. flavescens* occurred in Tasmania. Colonel Paterson, Lieutenant Governor of Tasmania from 1804 to 1810, who founded Launceston, was keenly interested

in plants and sent specimens to Sir Joseph Banks, and to Robert Brown after the latter returned to England in October 1805 (Hooker 1859).

Paterson's great friend and companion R.C. Gunn was outstanding amongst the further half dozen keen naturalists and collectors in Tasmania who added to the growing herbaria of Banks, Brown and later the Hookers, father and son. Gunn collected widely all over Tasmania between 1832 and 1850, at Circular Head, Emu Bay, Rocky Cape, the Asbestos Range and Hampshire Hills, the Western Mountains, Flinders and other Bass Strait Islands, the East Coast, Derwent Valley, St. Clair, Echo and Arthurs Lakes, west to Macquarie Harbour, and along the Franklin and Huon Rivers (Hooker 1859). Several of his *Stipa* specimens are cited by Hughes (1921, 1922). Unfortunately he chose to give each species rather than each specimen a collection number, so that the same number appears on several of his specimen sheets to the subsequent perplexity of taxonomists. Some incorrect original identifications led to further confusion.

Sir Joseph Hooker, who sailed with James Clark Ross as assistant surgeon and experimental botanist on the Antarctic Voyage of H.M. discovery ships *Erebus* and *Terror* (1839-43), visited Tasmania twice and stayed with Sir John Franklin. The latter, founder of the "Tasmanian Society" (1842), a part forerunner of the Royal Society of Tasmania (*Comme.* Dr. William Bryden in the Clive Lord Memorial Lecture: "Tasmanian Science and Scientists in the 1840's" delivered to the Royal Society of Tasmania 3.4.1973), and a friend of Sir William Hooker (Sir Joseph's father), was Sir Joseph's host from the end of July to 12th October, 1840, and again from 6th April to 6th July, 1841, both of which were winter periods. During his second visit, Hooker examined the fossil forests at Rosegarland Estate (Allan 1967, p. 125), from whence came the splendid conifer trunk which adorns the entrance to the Geological Section at the British Museum. He included four species of *Stipa* in the FLORA TASMANIAE (Hooker 1855-60), of which *S. flavescens* Labill. and *S. setacea* R. Br. were based on records in the earlier publications of Labillardière (1804) and Brown (1810), while *S. semibarbata* R. Br. and *S. pubescens* R. Br. were from his own observations "common on dry soils". Subsequent investigation (Townrow 1978, p.254) has shown that he was not justified in placing *S. pubinodis* Trin. in synonomy with *S. pubescens*. He also confused *S. setacea* with what was later distinguished as *S. variabilis* Hughes, and found it impossible to separate *S. semibarbata* and *S. mollis* R. Br. The latter separation is still a matter for conjecture (Townrow 1978, p.245).

Others who contributed to the pool of Tasmanian *Stipa* herbarium material during the 19th century include John Llotsky, who was active in the Tasmanian Alps in 1830, whose collections were dispersed (Hooker 1859), Captain Home who collected *S. stuposa* Hughes from Port Arthur and Hobart Town in 1848, and W.H. Archer F.L.S. Archer, Registrar General of Victoria from 1859, was a keen statistician whose strong botanical and zoological interests were encouraged by Baron F. von Mueller. He collected a Herbarium of Tasmanian Plants (Nairn *et al.* 1969). Mueller himself collected *S. pubinodis* from the Latrobe River Area (Mersey River, 1854, *Mueller*). S.G. Hannaford, editor of the Launceston Times, and later (1870) Librarian of the Tasmanian Public Library at Hobart (Mennell 1892) also kept a Herbarium of Tasmanian Plants. Some *Stipa* specimens from the Archer, Mueller and Hannaford collections are at Hobart (H) while Home's specimen of *S. stuposa* is at the British Museum of Natural History (BMNH).

The Rodway period 1890-1930

Leonard Rodway, Honorary Botanist to the Tasmanian Government from 1896 to 1932, was also dentist on the honorary staff of the Hobart Hospital (Chisholm *et al.* 1958). He made extensive collections of plants in southern Tasmania, and left numerous *Stipa* specimens which were collected from areas between Brighton and Dromedary north of Hobart, to Blackmans Bay in the south. His specimens at Hobart and Kew have collecting dates ranging from 1890 to 1935.

Historical notes on *Stipa* in Tasmania

Five *Stipa* species are listed by him in the TASMANIAN FLORA (Rodway 1903): *S. pubescens*, *S. setacea*, *S. flavescens* and *S. semibarbata* were retained from Hooker's list (1855-60), with the further addition of *S. teretifolia* Steud. and a new variety, *S. pubescens* var. *aphylla* Rodway.

Four of Rodway's contemporaries deposited specimens of Tasmanian *Stipa* at the National Herbarium of New South Wales (NSW). J.H. Maiden, Curator of the Technological Museum Sydney from 1881 (Johns 1922), and R.H. Cambage, Chief Mining Surveyor (N.S.W.) (Johns 1922) together collected *S. stuposa* at Sandy Bay in January 1902. J.B. Cleland, Professor of Pathology at Adelaide University, a keen ornithologist and botanist and later president of the Royal Society of New South Wales (1917) (Legge 1971, 2), collected *S. mollis* at Launceston in November 1912. A.H.S. Lucas, a scientist and schoolteacher in Sydney and Professor of Mathematics at the University of Tasmania for two years (Legge 1971, 5) collected many plants while in Hobart in December 1923, among which were *Stipa teretifolia (=S. stipoides)*, *S. variabilis* and *S. semibarbata*.

The post 1920's period of inertia

Dwindling interest in taxonomic botany after the 1920's was reflected in *Stipa* research by a paucity of collected specimens and a dearth of publications.

The ensuing twenty years of *Stipa* collecting in Tasmania are represented by four specimens: 1926, *Black* (K); 1931, *Davies* (NSW) (William Davies of the Welsh Plant Breeding Institute, Aberystwyth); 1932, *White* (NSW) (C.T. White, Government Botanist, Queensland); and Jan 1937, *G.* and *C. Davis* (NSW).

The Curtis period 1943 to the present time

Dr W.M. Curtis, was appointed to the Botany Department of the University of Tasmania in 1943 retiring at the end of 1966. She has maintained a profound interest in taxonomic botany, and has collected widely throughout the State. Her specimens of *Stipa* (1943-59) await treatment for the Monocot section (Part 4) of the STUDENT'S FLORA OF TASMANIA, to be published shortly (Curtis, 1956-).

N.T. Burbidge, Curator of Herbarium Australiensis, C.S.I.R.O., Canberra, S.T. Blake, Research Botanist, Division of Primary Industries, Brisbane, and J.W. Vickery, National Herbarium Sydney, came to Hobart to attend the A.N.Z.A.A.S. Conference of 1949, and made *Stipa* collections on the A.N.Z.A.A.S. botanical excursions. Duplicate sheets of these collections were subsequently deposited at Kew, Hobart, Sydney and Canberra.

Dr. Vickery revisited Tasmania with Dr. M.E. Phillips (Botanical Gardens, Canberra) in January 1962 and collected *Stipa* and other specimens for the Canberra Botanical Gardens Herbarium.

The current work on *Stipa* (Townrow 1970, 1974, 1978) commenced in 1965 with general collecting and recording of distribution of taxa. The study of type specimens on long loan from Kew has greatly facilitated an understanding of the genus both in Tasmania and in Australia as a whole.

THE TYPE LOCALITY OF *STIPA FLAVESCENS* LABILL.

The question of the identity of the enigmatic *S. flavescens* and its possible conspecificity with the well accepted taxon *S. compacta* Hughes revolved round two main issues: firstly the re-examination of the leaf blade section of the type of *S. flavescens* to obtain verification of Hughes' data; secondly the discovery of new specimens which would match the type of *S. flavescens*. That specimen has cleistogamous florets with *S. compacta*-like lemma characters coupled with thickened, terete leaf blades and membranous hairless ligules up to 4mm long.

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Re-examination of a leaf blade section of the type of *S. flavescens* revealed a lignification pattern agreeing with that shown in Hughes' drawing for *S. compacta* (Hughes 1921, p.29, fig. 31a) not as in that for *S. flavescens* (*l.c.* p.19, fig. 6a) so that a search for specimens having leaf blades with a continuous hypodermis was no longer necessary.

It was assumed that the best place to look for new specimens matching the type material would be the type locality if that could be rediscovered.

As in the case of *Stipa elegantissima* Labill., and *Leptospermum glaucescens* Labill. (Willis 1967), Labillardière occasionally by mistake wrote "in capite van Diemen" instead of "in terra van Leuwin" and vice versa on some of his specimen labels. Therefore it was possible that *S. flavescens* might have come from Western Australia and not Tasmania as he stated (1804).

That *S. flavescens* was first collected in Tasmania, and the whereabouts of the type locality, is established with reasonable certainty by the ecological and historical evidence which follows.

The type sheet of *S. flavescens* at Kew has on it three packets which contain loose bits of plant material. Packet 1 labelled "originally stuck on sheet" in Hughes' handwriting, contains lemmas and loose bits from the type collection. Packet 2 contains lemmas sorted out of the material in Packet 1 by P.F. Morris and labelled by him *"S. pubescens"*. Packet 3 contains bits taken from a panicle of the type collection of *S. flavescens*. The lemmas in Packet 2, I identify as belonging to the endemic Tasmanian species *Stipa aphylla* (Rodway) Townrow. Thus the type specimen of *S. flavescens* must have been collected from Tasmania and not from Western Australia.

The endemic *S. aphylla* is restricted to the margins and open areas of dry sclerophyll in coastal and near coastal parts of south-eastern Tasmania with rainfall under about 1020mm p.a. (Townrow 1974). Its major flowering period begins in early December and ends at the beginning of February, about two weeks earlier than that of *S. flavescens* (called *S. compacta* in Townrow 1974) which grows in low coastal sandy areas, and flowers from mid-September to mid-July. Therefore it is most probable that the type material of *S. flavescens* was collected, along with *S. aphylla*, no later than late February or very early March close by or at the margin of dry sclerophyll in a low coastal sandy area. I have recorded *S. flavescens*, then ascribed to *S. compacta*, growing in the vicinity of *S. aphylla* on one occasion only (in January 1974, see below) and regard it as an unusual combination in present day circumstances as most of the appropriate low lying dry sclerophyll has been cleared for grazing.

Labilladière's first visit to Tasmania (23 April-28 May 1792) was too late in the season for the collection of both *S. flavescens* and *S. aphylla* in flower, therefore he must have collected them during his second visit between 22 January-1 March 1793. Even so, this was very late in the flowering season, which circumstance explains the poor quality of his *Stipa* specimens.

Only two areas visited between 22 January and 1 March 1793 fulfil the habitat requirements for the type locality of *S. flavescens*. They are Pointe de Riche (Simpson's Point) on the western side of the Baie de l'Isthme (Simpson's or Isthmus Bay), and the tip of Cap le Grand (Kinghorne Point, west of Robert's Hill), both on Bruny Island. Other areas such as those around Recherche Bay are too wet. Partridge Island, which is not too wet, is ruled out because Labillardière called there too late in the season (20 May 1792); also a search of this Island made in 1974 on the anniversary of his visit revealed no *S. aphylla* and only one depauperate specimen of *S. flavescens*. Figure 1, which shows the possible type localities, is based on a combination of a tracing of Beautemps-Beaprè's "Carte Particulaire du Canal D'Entrecasteaux

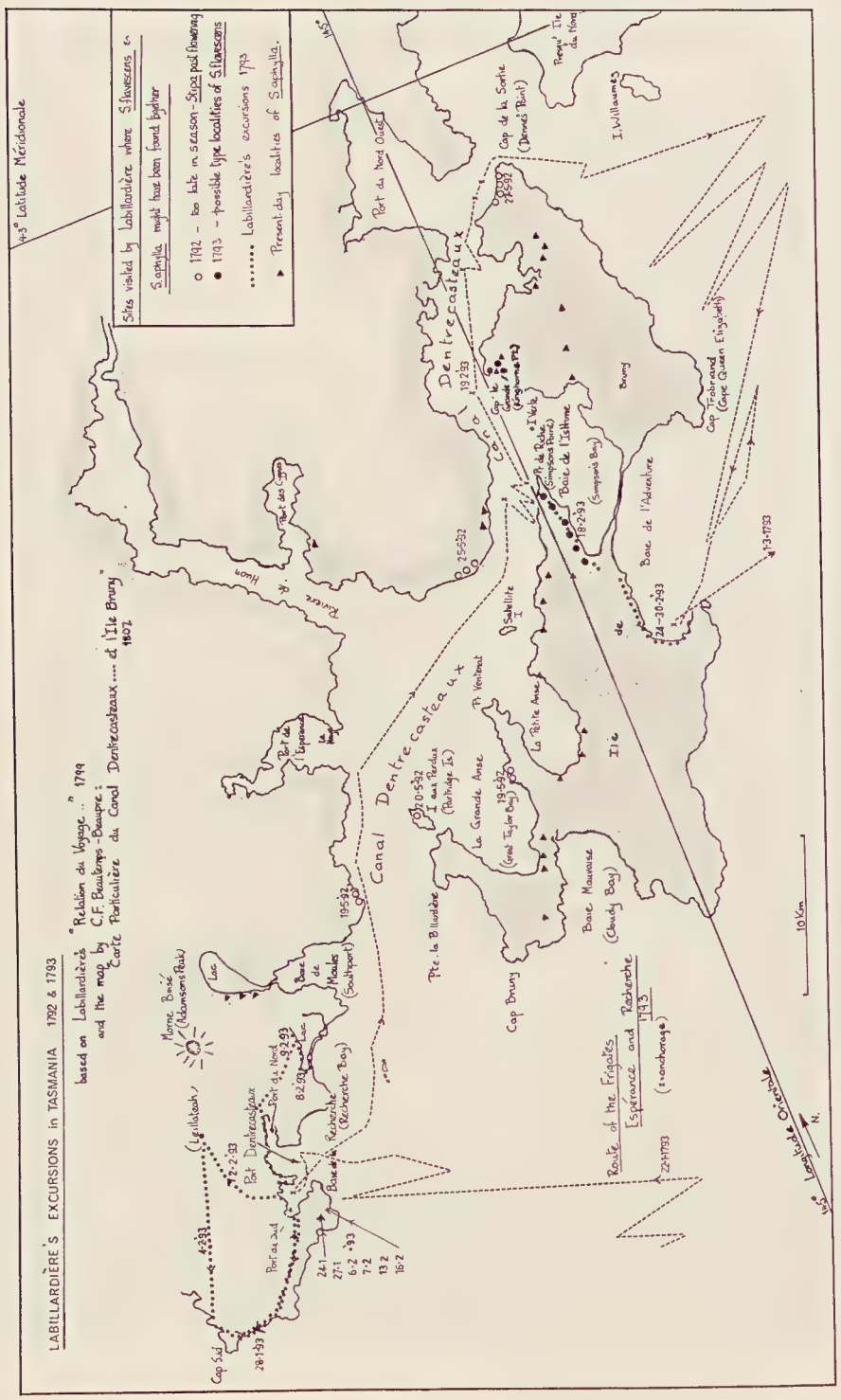
LABILLARDIÈRE'S EXCURSIONS in TASMANIA 1792 & 1793
based on Labillardière's "Relation du Voyage ..." 1799
and the map by C.F. Beautemps-Beaupré: "Carte Particulière du Canal Dentrecasteaux .... de l'Ile Bruny" 1807
Sites visited by Labillardière where S.flavescens & S.aphylla might have been found together
○ 1792 - too late in season - Stipa past flowering
● 1793 - possible type localities of S.flavescens
..... Labillardière's excursions 1793
▸ Present-day localities of S.aphylla.
43° Latitude Méridionale
Canal Dentrecasteaux
Cap Sud
Port Esperance
Port Cockburn
Port du Nord Ouest
Port du Nord
Port du Sud
Port Esperance
Baie de Recherche (Recherche Bay)
Baie de Moules (Southport)
Pte. la Billardière
Cap Bruny
Baie Mauvaise (Cloudy Bay)
La Grande Anse
La Petite Anse
Pte. Venteat
Isthme de Tasman
Baie de l'Adventure
Cap Frobrand (Cape Queen Elizabeth)
Cap de la Sortie (Darwin Point)
Pte. de Roche (Simpsons Point)
Baie de l'Isthme
Baie (Simpsons Bay)
Bruny
I. Williams
Route of the Frigates Esperance and Recherche 1793
(+anchorages)
10 Kms
N.

FIG. 1. - Sketch map of Bruny Island and the adjacent Tasmanian Coastline based on a tracing of C.F. Beautemps-Beaupré's map of 1807, showing the sites visited by Labillardière in 1792 and 1793 where *Stipa flavescens* might have been found in association with *S. aphylla* i.e. where the annual rainfall is less than about 1020mm, close by or at the margin of dry sclerophyll in a low lying sandy area. (Also figured are Labillardière's excursion routes of 1793).

et l'Isle Bruny" in his ATLAS DE VOYAGE DE BRUNY - D'ENTRECASTEAUX (1807, pl. 39, fol.) included in De Rossels' VOYAGE DE D'ENTRECASTEAUX (1808), and of Labillardière's own account of his collecting expeditions (RELATION .... 1799, held at Kew Herbarium Library). The following extract from RELATION, 2, translated from the French, describes Labillardière's visits to Pte. Riche and Cap le Grand:-
"18th February [1793]: Got underway but had to anchor again because of the contrary current and faint winds [the anchorages for 17th and 18th February are marked close together on the map, fig. 1 just off Pte. de Riche]..... Natives appeared on the eastern shore. I hastened on shore..... one of the natives remembered Bligh's visit.. ... I walked with the natives towards Adventure Bay and then returned [to the Recherche]. Soon after sunset we weighed anchor and proceeded two leagues further and anchored. 19th February: Landed on the eastern shore and penetrated the woods where I found a new species *Exocarpus expansa*..... We were under sail by 5 p.m. We took four days to cover the couple of leagues to the extremity of the strait."

Both Pointe de Riche and Cap Le Grand, the areas suggested as type localities, are much exposed to prevailing winds, especially the western end of Cap Le Grand (Kinghorne Point and Roberts Hill). Such a bleak environment might be responsible for the thicker, more terete leaf blades and different ligule development of the type material of *S. flavescens* compared with the more usual characters as exemplified by the type material of *S. compacta*. The type specimen of *S. flavescens* shows evidence of cleistogamy (minute anthers and well developed caryopsis, Townrow 1978, p.240) which again may be connected with extreme environmental conditions. Thus the type may be a phenotypical variant of the more usual form.

Visits to both localities were made, approaching both by sea and by land, to Simpsons Point on 23 December 1973, and to Kinghorne Point on 23 December 1973 and 11 January 1974, those dates being the closest possible to arrange to the anniversary of Labillardière's visit.

S. flavescens (then assigned to *S. compacta*) was recorded at both localities growing in a few isolated patches immediately behind the strandline. *S. aphylla* was absent from Simpsons Point, but was discovered on 11 January 1974 near Kinghorne Point scattered in sparse woodland, some within 10m of the pebbly strandline, and about 400m from the closest patch of *"S. compacta"* (see fig. 2 at ▲ and plate 1 "↘"). The patch of *"S. compacta"* was situated on low sandy banks at the mouth of the small creek running into the inlet north east of Snake Island (see fig. 2 at ✱ and plate 2). This spot with its promise of fresh water is an obvious landing place for Labillardière to have chosen from the anchorage of 19 February 1793 (fig. 2 at ⚓).

Detailed examination of representative specimens (Townrow 255 (HO)) ascribed to *S. compacta* collected from this site was made. All leaf blade sections agreed with Hughes' drawing of *S. compacta* sections. The lower culm leaves of several specimens had lopsided ciliate margined ligules up to 1mm long intermediate between those of the types of *S. flavescens* and of *S. compacta*, while the florets were cleistogamous like those of the type of *S. flavescens*. Although specimens exactly matching the type of *S. flavescens* in ligule character (membranous, up to 4mm, smooth margined) were not found, there is little reason to doubt that *S. flavescens* and *S. compacta* are conspecific.

Taking all evidence into consideration, the most likely site of the type locality of *S. flavescens* is the sandy bank area at the north end of the inlet north-east of Snake Island south of Roberts Hill, North Bruny Island (latitude 43° 10'S, longitude 147° 18') (plate 2).

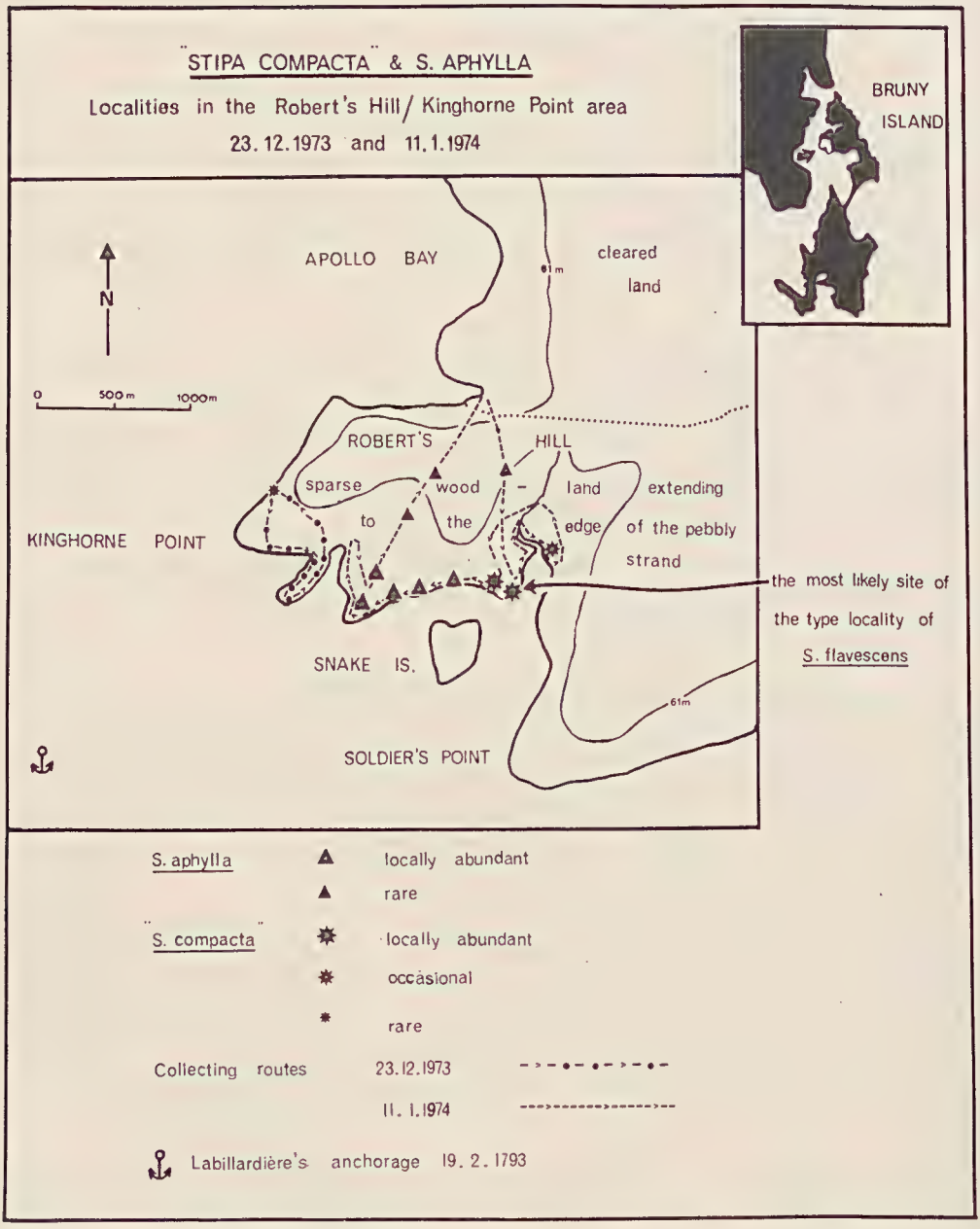

FIG. 2. - Sketch map of the Roberts Hill region of Bruny Island showing the author's collecting routes and recorded localities of *"Stipa compacta" (=S. flavescens)* and *S. aphylla*, Labillardière's anchorage in February 1793, and the most likely site of the type locality of *S. flavescens*.

PLATE 1. - Labillardière's probable landing place on 19 February 1793 - the inlet east of Kinghorne Point and north east of Snake Island; *S. aphylla* is marked with a white arrow. (Photograph taken looking west to Woodbridge).

PLATE 2. - The most likely site of the type locality of *S. flavescens* - *S. flavescens* growing on the sandy bank at the north end of the inlet north east of Snake Island. (Photograph taken looking east).

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THE GENUS *STIPA* IN TASMANIA

PART 3 - REVISED TAXONOMY

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(with four tables, 15 text-figures and two plates)

ABSTRACT

The twelve indigenous *Stipa* species occurring in Tasmania are revised. These are *S. aphylla* (Rodway) Townrow (endemic), *S. bigeniculata* Hughes, *S. elelandii* Summerhayes and Hubbard, *S. falcata* Hughes, *S. flavescens* Labillardière, *S. nervosa* var. *neutralis* Vickery, *S. mollis* R. Brown, *S. semibarbata* R. Brown, *S. pubinodis* Trinius and Ruprecht, *S. stipoides* (Hooker) Veldkamp, *S. stuposa* Hughes (endemic) and *S. variabilis* Hughes.

A key to species is based on both floral and vegetative characters. Emended species descriptions are based on type and/or matched specimens augmented by extensive Tasmanian collections. Detailed figures produced at standard magnifications of each species illustrate new characters of specific significance including adaxial leaf surface ornamentation figured in scanning micrographs and numerous details of floret structure.

S. elatior Hughes and *S. compacta* Hughes are reduced to synonomy with *S. flavescens* Labillardière. *S. aphanoneura* Hughes, *S. setacea* R. Brown, *S. pubescens* R. Brown, *S. elegantissima* Labillardière, *S. laeviculmis* Nees, *S. eremophila* Reader, and *S. hemipogon* Bentham are excluded names.

The appendix includes a collectors' index (Tasmanian specimens), text tables and descriptions, and figures of *S. nervosa* Vickery, *S. pubescens* R.Br. and *S. blackii* C.E. Hubbard closely allied to and previously confused with *S. nervosa* var. *neutralis*, *S. pubinodis* and *S. stuposa* respectively.

INTRODUCTION

The genus *Stipa*, first proposed by Linnaeus in 1753, commonly known as "spear-grass", belongs to the tribe Stipeae (Dumortièr 1823) which is placed second by Stebbins and Crampton (1961) in the sub-family Festucoideae between Amplodesmeae and Brachyelytreae.

Stipa, with at the latest estimate some 300 species (Johnson in Younger and McKell 1972, p.30), is the largest genus in that tribe. The species are mostly xerophytic, many having inrolled or even bristle-like blades. They are widely distributed in temperate or warm temperate regions of the world including parts of North and South America, Russia, Europe, Asia and Australia. Between 60-70 species have been described for Australia, where they are typically constituents of desert grassland. Twelve native species, of which two are endemic and two introduced species, are known to occur in Tasmania.

The genus includes a number of useful forage species which contribute to animal feed in spring and autumn in otherwise unproductive arid areas of the world. In the native pastures of Southern Australia *Stipa* is co-dominant with *Danthonia*, and together the two form the most characteristic disclimax of the savannah woodlands.

Such grassland, although never producing large quantities of feed, has the reputation of maintaining healthy sheep with high quality wool (Leeper 1970). During the flowering season however the sharp pointed fruits of *Stipa* can be very troublesome, especially to sheep, piercing mouths and feet and causing sores or even death (Mulham and Moore 1970).

A survey of all the Australian members of the genus would have wide implications of great taxonomic interest. It should include all the classical morphological and, more particularly, the nonmorphological characters which in the last quarter century have proved of such significance in the natural classification of the Gramineae (tabulated by Prat 1960, p.34 *et seq.*). For instance a knowledge of embryo structure regarding the presence or absence of an epiblast, and lodicule morphology and number (two or three), will give insight into the relationship of Australian species with other *Stipa* floras in North and South America, in Africa and in Eurasia.

The presence of an epiblast in Stipeae has been noted by most authors, including Reeder (1957), Jacques-Félix (1962), de Winter (1965) and Matthei (1965). Gould however (1968) states that "the embryo [in Stipeae] is festucoid, except in the absence of an epiblast". He could simply have made a printing error, but may have had evidence, to which he does not refer, to support his opposing claim. The present author, in a preliminary investigation of the embryo of the single Australian *Stipa* so far examined, could find no epiblast (see fig. 6, H). Obviously much more careful and detailed study is required before the facts can be fully discovered and appreciated, but it appears at least a possibility that an epiblast is not universally present in *Stipa* and may be absent from some North American and Australian species.

The systematic importance of the lodicules, those minute scales at the base of the ovary between the lemma and the palea, is beyond dispute (review, Jiraśek 1969). Several recent authors on *Stipa* including de Winter (1965) and Matthei (1965) have recognised the significance of lodicules. Matthei *(loc. cit.)* in his descriptions of Chilean *Stipa* based his primary grouping of species on a lodicule number of two or three per floret. The present author on the other hand has found that the number of two or three lodicules per floret may be related to the occurrence of cleistogamy and may vary within the species, as for example in *S. mollis*. The number of lodicules should not therefore be used as a character for grouping Australian *Stipa* (unpublished drawings and data).

Future anatomical studies should include not only a survey of leaf anatomy, but also awn anatomy. Serial sectioning of awns may for instance be used to produce supporting evidence if some of the Australian species now included in *Stipa* are in reality species of *Aristida* with fused lateral awns. (See Elias 1942, de Winter 1965).

The genus is of considerable significance in palaeogeographical studies. *Stipa*-like grasses are among the earliest known fossil grasses with an origin perhaps as far back as the mid-Cretaceous (Elias 1942), and the genus is at present distributed in virtually all the great land masses. By virtue of its palaeohistory and its relation to other parts of the world as indicated by theories of continental drift and tectonic plate movements (see Cox, Healey and Moore 1973), Australia occupies a key position in the development of distribution patterns of many forms of plants and animals having their origins in Cretaceous times before the complete breakup of Gondwanaland and Laurasia. A study of Australian *Stipa* species covering all the aspects associated with 'Omega' taxonomy would contribute to a wider knowledge of present day variations within the genus as a whole, and could provide valuable clues to the history of the tribe, so helping to clarify the possible migration routes taken by the earlier progenitors.

The genus is of minor importance in Tasmania, where nine of the twelve native Australian species recorded for the State contribute to the familiar roadside flora

of the drier lowland and coastal areas. It is noticeable that in Tasmania *Stipa* is largely confined to roadside and similar ungrazed areas, and is mostly absent from the unimproved pastures possibly having been grazed out by sheep.

Apart from papers by the author (1969, 1970, 1974) no information has been published on *Stipa* in Tasmania since Rodway's treatment of the genus in THE TASMANIAN FLORA (1903), except that Willis records eleven species for Tasmania in A HANDBOOK TO PLANTS IN VICTORIA (1962, 1970).

The introduced species *Stipa miliacea* (L.) Hoover and *Stipa trichotoma* Nees are more familiarly known in Australia as *Oryzopsis miliacea* (L.) Benth. and Hook. f. ex Aschers and Schweinf. (Rice Millet), and *Nassella trichotoma* (Nees) Hack. ex Arech. (Serrated Tussock) respectively.

In Tasmania at least, they are very distinct from the native Australian *Stipa* species, and had there been no contribution to the taxonomy of the tribe Stipeae from American researchers (Corti 1951; Hoover 1966; Caro 1966) they would certainly be regarded as belonging to genera different from *Stipa*. In recent Australian taxonomic literature (Willis 1970, p.188; Burbidge 1970, p.56; Burbidge and Gray 1970, p.54) the two species still appear under their older epithets though in the last named work it is noted that "*Nassella* is placed under *Stipa* in current works on South American grasses but left under *Nassella* here to avoid confusion in popular usage". *S. trichotoma* also appears as *Nassella trichotoma* in recent weed control publications (e.g. Watson and Morris 1973). Both introduced species are of significance in Tasmania, *S. trichotoma* is a scheduled noxious weed which poses a threat to grazing lands which through great effort has been confined to small areas in the south and east of the State (Watson and Morris, *op. cit.*). *S. miliacea* is a familiar inhabitant of waste areas and roadsides in the drier lowland areas associated with human habitation. Apart from appearing in the key to related genera and the key to species, these two species have been excluded from this revision which covers the native species of *Stipa* only.

Future taxonomic investigation of Tasmanian *Stipa* species should include studies on the variability of populations, chromosome numbers, breeding systems, structural heterozygosity, the presence and type of polyploids, the degree to which the species can be crossed, the detection of hybrids (*c.f.* Johnson *et al.*, 1943 *et seq.*) and the presence and extent of introgression (*c.f.* Anderson, 1949, 1956), plus detailed habitat studies.

The appearance of apparently hybrid swarms of plants in the field, with characters intermediate between putative parent species, e.g. *S. semibarbata/S. stuposa*, *S. mollis/s. semibarbata*, suggests that some of the Tasmanian species are inter-fertile. Chromatographic techniques such as those used by Alston and Turner on hybrid populations in the genus *Baptisia* (1963) could be used to identify the parent forms and reveal other hybrids (see Solbrig 1970, p.165).

The extent and phenotypic effects if any of cleistogamy and associated anther and lodicule sizes requires investigation. The breeding mechanisms and the kinds and effects of isolating barriers within and between the species, including an analysis of the sorts and amounts of hybridization must be understood before the true biological situation in Tasmanian and Australian *Stipa* as a whole can be clarified.

Materials and Methods

Specimens examined.

The revision is based on a reappraisal of the type material supported by examination of collections made in Tasmania between 1966 and 1971. The majority of type specimens of Australian *Stipa* formerly unavailable in Australia, is contained in the Australian *Stipa* collection at Kew Herbarium (K). These were examined by the author

in England in 1970, when type and matched specimens were selected and subsequently loaned for study in Hobart between 1971 and 1976. Drawings of 15 of these specimens are included in the species descriptions.

The Tasmanian species in the *Stipa* collection at the British Museum (BM), also examined in 1970, were found to be mostly useless for detailed study because of re-mounting methods used in repairing war damage. Whole specimens including delicate inflorescenses and culms are completely stuck down to the mounting sheet, rendering diagnostic features obscure and inaccessible. Dr. Launert of the Botany Section (European Flora) made a preliminary set of micrographs of adaxial leaf surface ornamentation of ten species using the British Museum's Scanning Electron Microscope unit.

Other type specimens examined were loaned from Florence (*S. flavescens* Labill. (FI)), Leningrad (*S. pubinodis* Trin. and Rupr. (LE)) and Adelaide (*S. semibarbata* var. *gracilis* Black (AD)).

The Tasmanian species in the *Stipa* collections in the eastern Australian State Herbaria of Adelaide (AD, ADW), Canberra (CANB, CBG), Hobart (HO), Sydney (NSW), and Melbourne (MEL) were examined during a preliminary study in August 1969.

Apparatus and techniques. Herbarium and fresh specimens were examined by means of an Olympic Zoom Stereo microscope mounted on a Universal Stand VS/IV and a Leitz Monla Universal Lamp fitted with a Bausch and Lomb Fiber Optics Stereo-Microscope Illuminator; measurements were made with an objective micrometer and an eyepiece micrometer at x10 and x40, and a Leitz x8 Measuring Lens. Floret parts were soaked for 5-10 minutes in dilute "Teepol" solution before dissection. The dilution of "Teepol" is not critical; in the usual procedure the tip of the dissecting needle was dipped in commercial "Teepol" and then stirred in about 5ml water. Lodicules, stamens and gynaecium parts were stained with dilute Methylene Blue.

The species drawings were based on type or matched specimens.

A survey of the adaxial leaf surface ornamentation (A.L.S.O.) of Australian species using the specimens loaned from Kew was made in collaboration with the late Dr. N.T. Burbidge (Plant Industry Division, C.S.I.R.O., Canberra) (February 1971). Polaroid Polapan Land Film was used to record A.L.S.O. viewed with the JSM-U3 Scanning Electron Microscope operated by Dr. B. Filshie and Mr. C. Beaton (Division of Entomology, C.S.I.R.O., Canberra).

For examination under the electron microscope, a fragment of blade about 3mm long and 2-3 ribs across, as plane as the curvature of the dry leaf would allow, was cut from the second or third leaf up from the culm base. The fragment was cut from the blade about 1mm up from the ligule with a slanting edge at the distal end to aid orientation. It was mounted on a stub using clear nailvarnish and then coated all over with Gold/Palladium (70%/30% by weight) in a vaporising chamber. Accelerating voltages of 12.5 and 5KV were used in viewing the specimens at magnifications of x80, x140 and x800. After examination, the coated specimens were replaced on the herbarium sheets for future reference.

The A.L.S.O. drawings in the species figures are tracings of x140 polaroid micrographs of part of the same areas represented in the relevant x80 plates of A.L.S.O., reduced by one half (plates 1 & 2).

Herbaria. Key to abbreviations (from Holmgren and Keuken, *Index Herbariorum, 1*, ed. 6 (Regnum Vegetabile, *92* (1974)).

AD State Herbarium of South Australia, Adelaide.

ADW Waite Agricultural Research Institute, Adelaide.

BM British Museum (Natural History), London.
CANB Herbarium Australiense, C.S.I.R.O., Canberra.
CBG Herbarium, Canberra Botanic Gardens, Canberra City.
FI Herbarium Universitatis, Florentinae, Firenze (Florence).
HO State Herbarium of Tasmania, The University of Tasmania, Hobart.
K The Herbarium, Royal Botanic Gardens, Kew.
LE Herbarium of the Department of Higher Plants, Leningrad.
MEL National Herbarium of Victoria, Melbourne.
NSW National Herbarium of New South Wales, Sydney.
US United States National Herbarium, Department of Botany, Smithsonian Institution, Washington.

Key to distinguish *Stipa* from related genera in Tasmania

1. a. Awn persistent, more than 20mm long; lemma cigar shaped or obovate .....2.
   b. Awn deciduous, less than 10mm long; lemma cylindrical-ovoid .....*Oryzopsis*

2. a. Lemma cigar-shaped, the callus sharp pointed and with its hair tuft less than half as long as the lemma; awn often massive .....*Stipa*
   b. Lemma obovate, broad and flat at summit, the callus blunt and with a hair tuft about half as long as the lemma; awn delicate .....*Nassella*

Stipa L. Sp. Pl. ed. 1, 78 (1753); Gen. Pl. ed. 5, 34 (1754)

Tufted, shortlived perennial, rarely annual grasses with convolute, sometimes flat leaf blades and with sheaths free to the base. *Ligule* membranous, often torn, or a membranous ciliate rim. *Inflorescence* a loosely spreading or contracted terminal panicle. *Spikelets* pedicelled, 1-flowered, hermaphrodite, chasmogamous and/or cleistogamous in the same inflorescence, very narrowly ellipsoid or terete; rachilla not produced beyond the base of the floret. *Glumes* hyaline or membranous, papery, often with long delicate tips, the lower 3-nerved, the upper 5-and-7-nerved, unequal, often several cm long. *Lemma* convolute, narrow, terete, indurated at maturity, hairy or glabrous, with a retrorsely hairy, pungent or rarely obtuse callus, tapering at the tip or minutely 2-lobed, terminating in a prominent awn; *awn* usually persistent, often disarticulating after dispersal, single, once- or twice-geniculate with a twisted column and delicate bristle, glabrous, plumose or variously hairy. *Palea* shorter than or equalling the enveloping hardened lemma, dorsally indurated and more or less hairy with membranous ventral margins, or hyaline; 2-nerved. *Lodicules* 2-3, hyaline, equal and large, or posterior member reduced, usually rounded at the apex, glabrous, indistinctly nerved. *Stamens* 3, the anthers elongate, often hairy at the tips, sometimes dimorphic (1 long, 2 short; rarely 1 short, 2 longer). *Caryopsis* tightly enclosed by the lemma and palea, free, fusiform-terete; hilum linear, nearly as long as the grain. (This description covers the native species in Australia. It does not include the introduced species *S. neesiana* Trin. et Rupr. which has a crowned lemma).

Type species: *Stipa pennata* L.

KEY TO SPECIES IN TASMANIA

Note: i. The species are numbered on the right hand side of the key in the order in which they are subsequently described as listed below. Figure and plate numbers correspond with the species numbers. In the species list, the brackets enclose species apparently with close affinities:

1. *S. aphylla* (Rodway) Townrow
2. *S. flavescens* (Labillardière) Townrow (= *S. compacta* Hughes)
   (= *S. elatior* Hughes)

3. *S. mollis* R. Brown
4. *S. semibarbata* R. Brown
5. *S. nervosa* var. *neutralis* Vickery
6. *S. pubinodis* Trinius and Ruprecht
7. *S. bigeniculata* Hughes
8. *S. clelandii* Summerhayes and Hubbard
9. *S. stuposa* Hughes
10. *S. stipoides* (Hooker) Veldkamp
11. *S. variabilis* Hughes
12. *S. falcata* Hughes

ii. *Stipa miliacea* (L.) Hoover, *Leafl. West. Bot.*, 10 (16), 340 (1966) = *Oryzopsis miliacea* (L.) Benth. and Hook. F. ex Aschers and Schweinf. *Mém. Inst. égypt. (Egypte)* 2, 169 (1887). *Stipa trichotoma* Nees in *Mart. Flor. brasil.* 2^1 (Agrostologia brasiliensis), 375 (1829) = *Nassella trichotoma* (Nees) Hack. ex Arech., *An. Mus. nac. Montevideo* 1^4, 336 (1896) [Caro 1966].

These species appear in the key but are not described in the text. They are not native to Tasmania so fall outside the scope of this paper. Caro, on the basis of the wide range of species available to him in South America, considers that *Stipa* and *Oryzopsis* should be merged, and he also supports Corti (1951) in placing *Nassella trichotoma* in *Stipa* in the section *Nassellopsis* Corti (Caro 1966).

In Tasmania these two species are very distinct from the other *Stipa* species and would not be considered to be in the same genus (see key to related genera.)

iii. Characters printed in "Elite" type may be determined in the field using a hand lens (x15); determination of characters in "*Script*" type requires higher magnifications (x40) and the use of a dissecting microscope.

1. a. Lemma cylindrical-ovoid, 2mm long; awn deciduous, less than 10mm long .....*Stipa (= Oryzopsis) mileacea*
   b. Lemma cigar-shaped or obovate; awn persistent, more than 20mm long .....2.

2. a. Lemma obovate, broad and flat at the summit, 1.5-2.0 mm long, the callus blunt with a hair tuft about half as long as the lemma; awn delicate ..... *Stipa (= Nassella) trichotoma*
   b. Lemma cigar shaped, 5mm or more long, the callus sharp pointed and with a hair tuft less than half as long as the lemma; awn often massive .....3.

3. a. Blades rigid, cylindrical, sharp pointed; a caespitose strandline plant up to 1m high, growing also in marginal areas of saltmarsh; A.L.S.O. of dense finger-like macrohairs .....*10. S.stipoides*
   b. Blades expanded, flat or folded; or blades absent .....4.

4. a. Blades absent or very tiny on flowering specimens, the culm leaves becoming reduced to brown sheaths and very small shrivelled ultimately shed blades; culms green, cane-like, 1-2mm diameter...*1. S. aphylla*
   b. Blades expanded and well developed, leaves not reduced and shed; A.L.S.O. of prickle hairs and/or macrohairs .....5.

5. a. Blades densely or moderately hairy on top surface (adaxial); A.L.S.O. composed of fine macrohairs *about 0.01mm (less than 0.02mm) diameter only* .....6.
   b. Blades hairless or only sparsely hairy on top surface; A.L.S.O.

of minute hooks and/or straight sided prickle hairs with or without macrohairs *0.02mm or more in diameter* .....8.

6. a. Ligule a densely bearded irregularly shaped membrane 1.5-2.0mm long; blades involute; awn plumose, the hairs about 2mm long .....*3. S. mollis*
   b. Ligule fingernail shaped or less than 1mm long .....7.

7. a. Ligule a somewhat hardened, rotund-obtuse (fingernail shaped), minutely hairy membrane about 2mm long (occasionally longer, sometimes lop-sided) on the lower leaves, the upper ligules shorter with fringed margins; blades convolute; lemma without crown hairs .....*6. S. pubinodis*
   b. Ligule a membrane less than 1mm long with a ciliate margin; blades involute; lemma crowned with hairs 2.5-5.0mm long.....*8. S. clelandii*

8. a. A.L.S.O. of minute antrorse prickle hair hooks only .....9.
   b. A.L.S.O. of sparse macrohairs in addition to minute prickle hairs .....:10.

9. a. Lemma-crown hairs 2-3 (-4)mm long; lemma lobes minute (up to 0.05mm) or absent; mature lemma light tan coloured (Munsell Hue reddish-yellow 7.5 YR 6/6); *A.L.S.O. hooks 0.02-0.03mm long* .....*7. S. bigeniculata*
   b. Lemma-crown hairs up to 0.5mm long; lemma lobes usually present but minute (0.1-0.6mm); mature lemma copper coloured (Munsell Hue dark reddish-brown 5YR 3/4); *A.L.S.O. hooks 0.03-0.05mm long* .....*2. S. flavescens*

10. a. Blades narrow, 1-2mm wide when unrolled, flexuous; lemma (body + callus) about 5mm long; awn falcate when dry; inflorescence very delicate .....11.
    b. Blades broad 2-5mm wide when unrolled; lemma (body + callus) about 10mm long; awn twice geniculate when dry .....12.

11. a. Blades needle-like, somewhat rigid, 40-80mm long; *awn column above articulation 0.25-0.32mm diameter* .....*12. S. falcata*
    b. Blades linear-involute, 50-150 (-250)mm long; *awn column above articulation 0.27-0.35mm diameter* .....*11. S. variabilis*

12. a. Blades involute; awn column minutely scabro-pubescent; *A.L.S.O. macrohairs up to 0.6mm long with swollen bases up to 0.04mm diameter* .....*5. S. nervosa* var. *neutralis*
    b. Blades convolute; awn column obviously pubescent .....13.

13. a. Lemma-crown hairs present, 1.5-3.0mm long; column hairs up to 1.0mm long; A.L.S.O. of prickle hair hooks and macrohairs, *the hooks up to about 0.05mm long*, mostly retrorse, *the macrohairs up to 0.05mm long, ca. 0.020mm diameter*, antrorse and retrorse, arising almost at right angles to the costal surfaces then bending ± sharply, shaggy on the lowest blade but becoming shorter and sparser on successive blades .....*9. S. stuposa*
    b. Lemma-crown hairs absent, column hairs up to 1.6mm long; A.L.S.O. of fine peg-like straight-sided prickle hairs and macrohairs, *the prickle hairs ca. 0.01mm long; the macrohairs up to about 0.4mm long, and about 0.025mm diameter*, mostly antrorse, erect, becoming shorter and sparser on successive blades .....*4. S. semibarbata*

Revised Taxonomy of *Stipa* in Tasmania

SPECIES DESCRIPTIONS

Notes

1. All specimens cited have been examined unless it is otherwise stated. An index to collectors is given in Appendix 1. Maps of floristic regions and/or divisions currently used in Western Australia, South Australia, New South Wales are available from the State herbaria. Tasmanian floristic zones are those defined in Specht, R.L. 1974: *Aust. J. Bot.* Suppl. Ser. 7, 320; those of Victoria in Specht *(loc. cit.)*, 451.
2. Useful diagnostic characters are underlined _____.
3. Apart from anthers and lodicules which were measured wet after a short soaking in dilute "Teepol" solution, all measurements were made on dry material.
4. The ranges of dimensions are based on a sample size of 25, the 25 composed of 5 measurements of each item for each of 5 plants of each species (2 only for *S. clelandii*). It is appreciated that this is a small sample on which to base conclusions. The sample size was determined in this case by practical considerations, and it does at least provide a starting point for further studies on species variation.

   Dimensions of features of adaxial leaf surface ornamentation were determined from the X140 scanning micrographs using a Leitz measuring lens with scale intervals representing 7μ (1/140 mm) read with an accuracy of ± 3.5μ (i.e. half a scale interval). The dimensions are mostly quoted in whole scale intervals.

   Where dimensions are expressed to two decimal places in mm the accuracy claimed is 0.01 (± 0.005)mm based on measurements made with the Stereomicroscope at X40 using a slide micrometer and an eyepiece micrometer with scale intervals representing 0.025mm (1/40 mm) read to the nearest half interval (± 0.01mm).

   In stating dimensions the word "length" is to be understood following the first figures given for each structure (in conformity with present European practice, see Heywood 1958).

   In an effort to gain a preliminary idea of the range of morphological variation within the species across the State, the specimens measured were chosen from localities as widely geographically dispersed as the existing Tasmanian collection would allow from as widely contrasting habitats as possible.

   In the case of every species, the dimensions of the type specimens came within the range of dimensions given in the descriptions.
5. The terms used to describe the adaxial leaf surface ornamentation (A.L.S.O.) are those of Metcalfe (1960) and follow the system of nomenclature used by Stewart (1965), and where applicable the lettering system developed by Prat (1932, 1960, 1961) and Prat and Vignal (1968) (stated in [ ] brackets):

   (a) Composition of ornament: This consists of macrohairs [P], prickle hairs [short P] and prickle hair hooks [P_1,P_2] alone or in combination. Microhairs and papillae are rarely found in Australian *Stipa*. *S. verticillata* Nees ex. Spreng. is the only Australian species which has apparently 2-celled microhairs [B_3] in addition to single-celled hairs.

   (b) Macrohairs and prickle hairs: The longest and shortest hairs visible were measured to give the range of length and approximate diameter at the base; the density of hairs varies from sparse to moderately to very dense; the direction of the long axis of the hair relative to the blade axis may be antrorse (towards the tip) or retrorse (towards the base of the blade), strongly or weakly ascending in various typical attitudes; most are single celled but some have a swollen basal cell or 'collar' protruding slightly from the surrounding epidermis.

   (c) Prickle hair hooks: The length was measured between the tip of the barb and the end of the base furthest from the barb, the diameter is the length of the base, both measurements made of hooks viewed at the sides of the costae where the effects of foreshortening are least troublesome.

   (d) Epidermal long cells: The approximate dimensions were determined from the scanning micrographs (x140). Some species have long cells with convex surfaces

which give the surface the appearance of the weave of a willow-stem or 'withy' basket [I_2]. This appearance can be recognised at x 40 magnification.
Note:
1. Silica cells: The shape, dimensions and arrangement of silica cells in the adaxial epidermal layer can be roughly ascertained from scanning micrographs (x140). Their proper study, not attempted in this project, would require the use of epidermal preparations (Stewart 1965, p.64). However, examination of the scanning micrographs indicates that the silica cells are dumb-bell shaped [S_4] as in all the Australian species and that in addition some species have irregularly rounded and/or nodular bodies. (Appendix 2A).
The presence of cross to dumb-bell or nodular silica bodies is used as a key character to *Stipa* by Watson and Milne in their key to sterile material of Black Mountain (A.C.T.) grasses (1972, p.346).
2. Wax platelets: These structures have been omitted from the descriptions although most species have numerous wax platelets scattered all over the epidermal surface. In some species the platelets may even obscure much of the minute surface detail.
3. Hairs in the furrows: These may be visible on scanning micrographs if the ribs are sufficiently wide apart and the furrows between them are not too obscure and deep.

6. Lemma colour is described using the Munsell Color chart System (Munsell 1954). Other lemma characters include those suggested in Townrow 1970, table 1.
7. Useful diagnostic features of the palea (usually neglected in descriptions) include (i) its length, the tip reaching to the top of the lemma or to some distance below it, (ii) the texture of the dorsal surface whether hardened like the lemma or more delicate, (iii) the tip whether hardened, or delicate and hyaline.
8. The Tasmanian species all have florets with dimorphic anthers, mostly one long and two shorter per set, but some species have in addition florets with either three equal anthers or a pair of equal longer anthers and a single shorter anther. At the same time the florets may be either chasmogamous or cleistogamous.
9. Although lodicule morphology is of established taxonomic significance (Jirásek and Jozífová 1968; Jirásek 1969) the author has followed the examples of Matthei (1965) and de Winter (1965) in recording lodicule number only for each species. Lodicules are figured, but at too low a magnification for depiction of structural detail.

1. *STIPA APHYLLA* (Rodway) Townrow, *Pap. Proc. R. Soc. Tasm.*, 104, 96 (1970).
(Figure 1; Plate 1, figure 1)
Syntype: Tasmania, Huon Road, Hobart; Rodway 995 (HO).
Syn. *S. pubescens* var. *aphylla* Rodway, TASMANIAN FLORA, 262 (1903).

Perennial, slender, erect, caespitose, up to 0.9m high, with very short condensed rhizomes about 3mm in diameter, the nodes about 3mm apart; *culms* rigid, *cane-like*, up to 1 (occasionally 2) mm in diameter, finely striate, smooth, glabrous, 3-4 noded, mostly light green but pale-yellow for 2mm above the node; *nodes* minutely pubescent. *Leaf sheaths* 4-18mm (about half the length of the internodes, finely striate, glabrous, becoming straw-coloured and somewhat inflated, ultimately shed after the blades; *ligule* up to 0.1mm, a minute membrane with a crenate minutely ciliate margin; *blades* up to 45mm in juvenile growth, stiff, involute, pointed, 1mm wide at the base when flattened, *shrivelling and shed as the inflorescence emerges*, *abaxial surface* smooth, *adaxial surface* ribbed, ribs c. 0.05mm wide (one half to one third width of ribs in other Tasmanian *Stipa* species), *A.L.S.O.* coarse moderately dense antrorse macrohairs and sparse antrorse prickle hair hooks, the macrohairs 140-350 x 15-20μ diameter at base, spikey with slightly swollen bases, alternating more or less regularly with the epidermal long cells in more or less regular rows, the prickle hair hooks 20-30 x c. 10μ diameter at base, the long cells 70-130 x c. 15μ wide. *Panicle* narrow, very loose, somewhat contracted when dry, with about 30 spikelets, 170 x 30mm wide, the main rachis

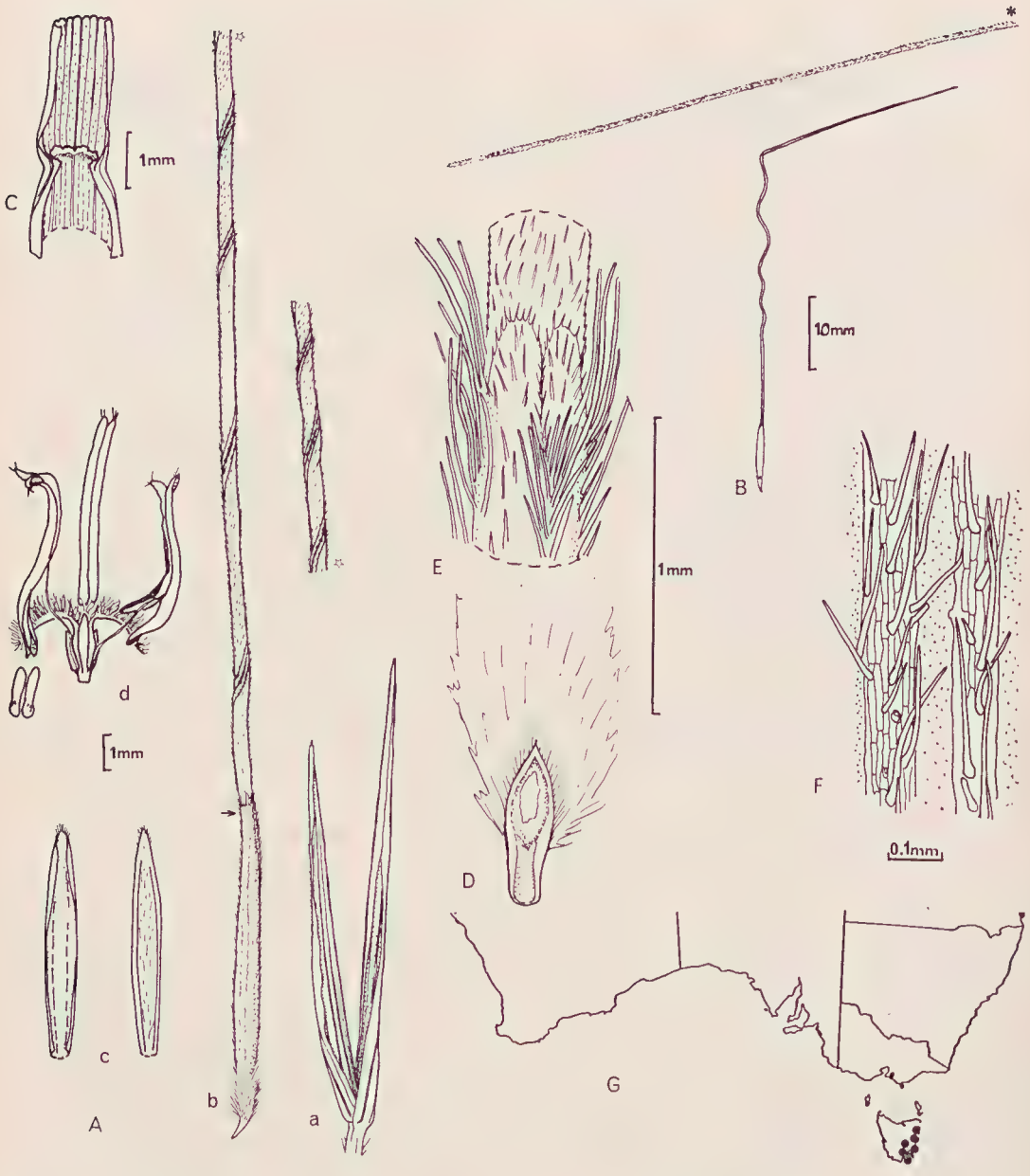

FIG. 1. - *Stipa aphylla* (Rodway) Townrow, "Townrow 4B" (HO) (matched with type specimen). Spikelet Characters:- A. a. glumes; b. lemma; c. palea, adaxial and abaxial views; d. lodicules, anthers, ovary x5. B. Lemma x1. D. Callus scar x 40. E. Lemma lobes x 40. Leaf characters:- C. Ligule (blade 1 from culm base) x7.5. F. A.L.S.O. x c. 80 (tracing of micrograph of part of area shown in Plate 1, fig. 1). G. Species distribution (cited specimens).

minutely scabrous, the branches very slender, upright, scabrous, 1-2-nate, the pedicels 10-20mm and clavate above. *Spikelets* with single floret, usually chasmogamous, pale-green to straw coloured above and purple below, with glumes widely divergent at maturity. *Glumes* thin, chaffy, unequal, narrowly linear-attenuate, slightly inrolled, *lower glume* 13.5-15.0 (-18.0) x c. 0.7mm wide when flattened, faintly 3-nerved, *upper glume* 12.5-15.0 (-15.5) x 1.0mm wide when flattened, 3-5 nerved, the lateral nerves of both glumes as strong as the mid-nerve. *Lemma* (7.5-) *8.0-11.0* (including callus tuft and tip) x *0.6-1.0mm* wide, firm, *linear, very dark greyish brown* (Munsell 10 YR 3/2-2/2), margins overlapping, body surface minutely pimpled (pimples c. 10μ diameter at base; *callus tuft* including sharp tip 1.6-3.5mm, pale yellow (Munsell 2.5Y 8/4), the *callus scar* (0.55-) 0.58-0.82 x c. 0.25mm wide; *lemma* lobes 0.10-0.37 (-0.60)mm (varying with maturity), minutely ciliate, the cilia up to 0.15mm, rarely absent; *lemma crown hairs* 0.10-0.80mm or absent; *awn* terminal, minutely pubescent, *the column* (38-) 40-51(-58) x 0.30-0.55mm diameter above articulation, dark brown, once (twice) kneed, (27-) 30-45mm to lower knee, *the bristle* up to 28mm, straw coloured, the awn hairs c. 0.1mm on column, 0.05mm and very dense on bristle. *Palea* (4.5-) 5.2-7.8mm, tip membranous, minutely hairy, reaching to c. 1.0mm below top of lemma, margins hyaline, dorsal surface as hard and hairy as the lemma between the two nerves. *Anthers* 2.5-5.1mm, three, either equal in length or 1 longer plus 2 shorter, or 1 shorter plus 2 longer. *Lodicules* c.1.5mm, three equal in length, the two anterior with swollen bases, the posterior not swollen at base.

TASMANIA. - East: 2 miles N of Bicheno, Jan 1965, *Townrow 298* (HO); Maria Is., Darlington, Nov 1968, *Townrow 205* (HO); Prosser R. near Orford, Nov 1967, *Townrow 24* (K); Copping, Jan 1949, *Blake 18277* (K); Eaglehawk Neck, Feb 1947, *Curtis 128* (K). South-East: Fern Tree, Ridgeway, June 1967, *Townrow 4B* (HO), Lower Pipetrack, Mar 1965, *297* (MEL); Hobart, Waterworks, Jan 1895, *Rodway* (HO), Huon Road, Univ. Tas., *995* (HO), Nov 1967, *Townrow 77* (HO), Jan 1970, *246* (K); Huonville, Anonymous (CANB 13186); Bruny Is., Barnes Bay, Dec 1968, *Townrow 147* (H); Channel Highway opposite Alonnah, S of Huon Pt., Jan 1967, *Townrow* (HO); Without definite locality, *Rodway* (K 484).

Distribution: apparently endemic and confined to SE Tasmania.

Ecology: marginal more open areas of undisturbed dry sclerophyll, below 330m altitude; often closely associated with, or growing out of clumps of *Lomandra longifolia* Labill.

Notes: *S. aphylla* closely resembles *S. muelleri* Tate (1885) of Victoria and South Australia, except that it is about half the size of the latter in all features, and may prove to be closely related, e.g., a member of a polyploid series containing both species.

2. *STIPA FLAVESCENS* Labill., *Pl. Nov. Holl.*, 1, 24 (1804); Hooker, *Fl. Tasm.*, 2, 110 (1856); Bentham, *Fl. Austral.*, 7, 566 (1878); Hughes, *Kew Bull.*, 1921, 6 (1921). (Figures 2, 2a; Plate 1, figure 2)

Lectotype: Tasmania, *Labillardière*, Webb (K35) [Here designated]. Syn. *Stipa scabra* var. *elatior* Bentham, *Fl. Austral.*, 7, 571 (1878). (*Lectotype:* Swan River, *Drummond 959* (K),) *Stipa elatior* (Bentham) Hughes, *Kew Bull., 1921*, 24 (1921). *Stipa compacta* Hughes, *Kew Bull., 1921*, 24 (1921); Townrow, *Pap. Proc. R. Soc. Tasm.*, 104, 85 (1970). (*Holotype:* Tasmania, 1837, *Gunn 996* (K).)

Perennial, robust, often caespitose; *culms* 0.4-0.8m, erect or somewhat geniculate, terete, 3-4 (-5)noded, the upper nodes exserted; *nodes* finely densely retrorse pubescent with felt of pale yellow hairs extending c. 10mm below node. *Leaf sheaths* slightly striate, eventually becoming loose, lower sheaths finely retrorse-hairy, grey brown, upper sheaths glabrous, yellowish green, outer sheath margins shortly ciliate or smooth; *ligule* c. 0.5mm, truncate, membranous, the margin minutely crenulate, ciliolate, with sparse white hair tufts up to 1.5mm on either side in the position of auricles; *blades 90-540 x 2-5mm wide*, linear, convolute, with long drawn out tips, somewhat harsh

and stiff, yellowish green, one or both margins often with orange coloured stripe about one third width of blade, *abaxial surface* smooth, occasionally sparsely retrorse-hairy below on lower culm leaves, *adaxial surface* hairless, very occasionally with a few scattered hairs near ligule, *A.L.S.O.* abundant antrorse prickle hair hooks 35-50µ with long oval bases 35µ x 15µ wide, the hooks progressively finer on blades higher up culms, epidermal long cells 20-90µ x c. 7µ wide with "withy basket" appearance at sides of costae. *Panicle* 150-300 x c. 20mm wide, exserted, open at flowering, afterwards dense and contracted, the longest branches 30-50mm to base of furthest spikelet occurring at lowest node, pedicels 2-12mm, branches and minor branches minutely scabrid hairy. *Spikelets* chasmogamous or cleistogamous, pale green tinged with maroon below, straw coloured above, with glumes widely divergent at maturity. *Glumes* subequal, subhyaline, acuminate, minutely scabrid on backs of mid-nerves, very minutely hairy between nerves, *lower glume* (9.8-) 11.0-15.0mm, conspicuously 3-nerved, *upper glume* (8.5-) 9.2-12.0mm, conspicuously 5-nerved. *Lemma* (7.5-_ 7.9-10.5 (-12.0) (including callus and tip) x 0.7-1.1mm wide, firm, spindle shaped, the colour varying with maturity, the immature brownish yellow (Munsell 10YR 6/8), the more mature dark reddish brown (Munsell 5YR 3/4) to dark brown (Munsell 7.5YR 4/4), with a coppery sheen produced by the indumentum of moderately, dense reddish yellow hairs (Munsell 7.5YR 7/6), the hairs 0.25-0.90 x 0.01mm diameter at base arising at c. 10° to body surface; lemma margins overlapping, upper one third of lemma surface minutely papillose; *callus tuft* including sharp tip 2.1-3.5 (-3.8)mm, varying in colour with maturity from white (Munsell 10YR 8.2) to strong brown to reddish yellow (Munsell 7.5YR 5/8 to 8/6), the *callus scar* (0.50-) 0.57-0.80 (-0.85) x 0.15-0.17mm wide; *lemma lobes* 0.05-0.38 mm, lanceolate, minutely hairy, margin ciliate, or lobes absent; *lemma crown* of about twelve hairs 0.5-1.3mm, uneven in length; *awn* twice kneed, minutely moderately densely hairy, the *column* 17.0-30.0 (-45.0) x 0.25-0.35mm diameter above articulation and 10.0-18.0 (-19.0)mm to first knee, hairs c. 0.12mm closely adpressed over whole column extending along bristle angles. *Palea* 4.5-6.5(-6.7)mm, the tip membranous, reaching to 0.4-0.75mm below top of lemma, dorsal surface between the nerves hard and hairy like the lemma, margins hyaline. *Anthers* usually 1 larger plus 2 smaller, more rarely equal; in chasmogamous florets the larger (1.0) 1.5-1.9 (-3.2)mm, the smaller 0.8-1.5 mm, in cleistogamous florets the larger 0.8-0.9mm, the smaller 0.4-0.6mm. *Lodicules*, three, of which the two anterior are longer and swollen, the posterior a tiny delicate thin membrane, in chasmogamous florets the anterior 2.0-2.5mm, the posterior 1.0-1.5 mm, in cleistogamous florets the anterior c. 1.5mm, the posterior c. 0.5mm.

WESTERN AUSTRALIA. - Darling: Claremont near Perth, sandhills near coast, Sept 1902, *Andrews* (K); Bow River, sandhills, Nov 1912, *Jackson* (K); Swan River, *Drummond 959* (NSW); Swan River, *Collie* (K). Warren: King George III Sound, *Brown 6202* (BM).

SOUTH AUSTRALIA. - Eyre Peninsula: Port Lincoln district, *French* (ADW 28130). Southern Lofty: Encounter Bay, Strand, Nov 1930, *Cleland* (K); Hindmarsh Is., Lower Murray River, Oct 1945, Anonymous (AD96323274).

NEW SOUTH WALES. - Central Coast: Sydney, Port Jackson, 1804, *Brown* (BM).

VICTORIA. - Western Coastal Plains; Port Fairy, dune on beach front, Nov 1959, *Symon 141* (ADW); Tower Hill at trigpoint (104m) more or less 3 km SSE of Koroit, Nov 1963, *Willis* (MEL). Central (Melbourne): Brighton Beach, Sept 1929, *Sonenberg* (K).

TASMANIA. - King Is.: SE coast at Grassy, Jan 1949, *Blake 18437* (K). North: Somerset, on sand dunes, Feb 1948, *Curtis 130* (K); Devonport, sandy foreshore, Dec 1931, *Davies* (K). South-East: South Bruny Is., Alonnah Beach, Nov 1966, *Townrow 15* (HO); Hobart, Nov 1929, *Rodway* (H), Upper Domain on E side of Radio Transmitter, Nov 1967, *Townrow 41* (HO); Lower Sandy Bay, sandy area by Nutgrove Car Park, Dec 1966, *Townrow 16* (HO), Dune to West of Nutgrove Car Park, Nov 1967, *28* (HO); Kingston, margin of brackish swamp, Brown's R., Dec 1944, *Curtis 20* (HO); Kingston Beach, Nov 1935, *Rodway 25* (HO); Blackmans Bay, sand dunes, Jan 1928, *Rodway* H117 (HO); North Bruny Is., Sandy bank near Shangri La Tea Gardens, S of Dennes Point, Jan 1968, *Townrow 144* (HO), Great Bay, sandy strip between road and beach, Jan 1970, *Townrow* (K), Variety Bay, old pilot station, Jan 1968, *157* (HO). North-East: Tomahawk, low dune beside beach, Dec 1967, *Townrow 112* (HO). East: Hobart, Old Beach, Eastern Shore,

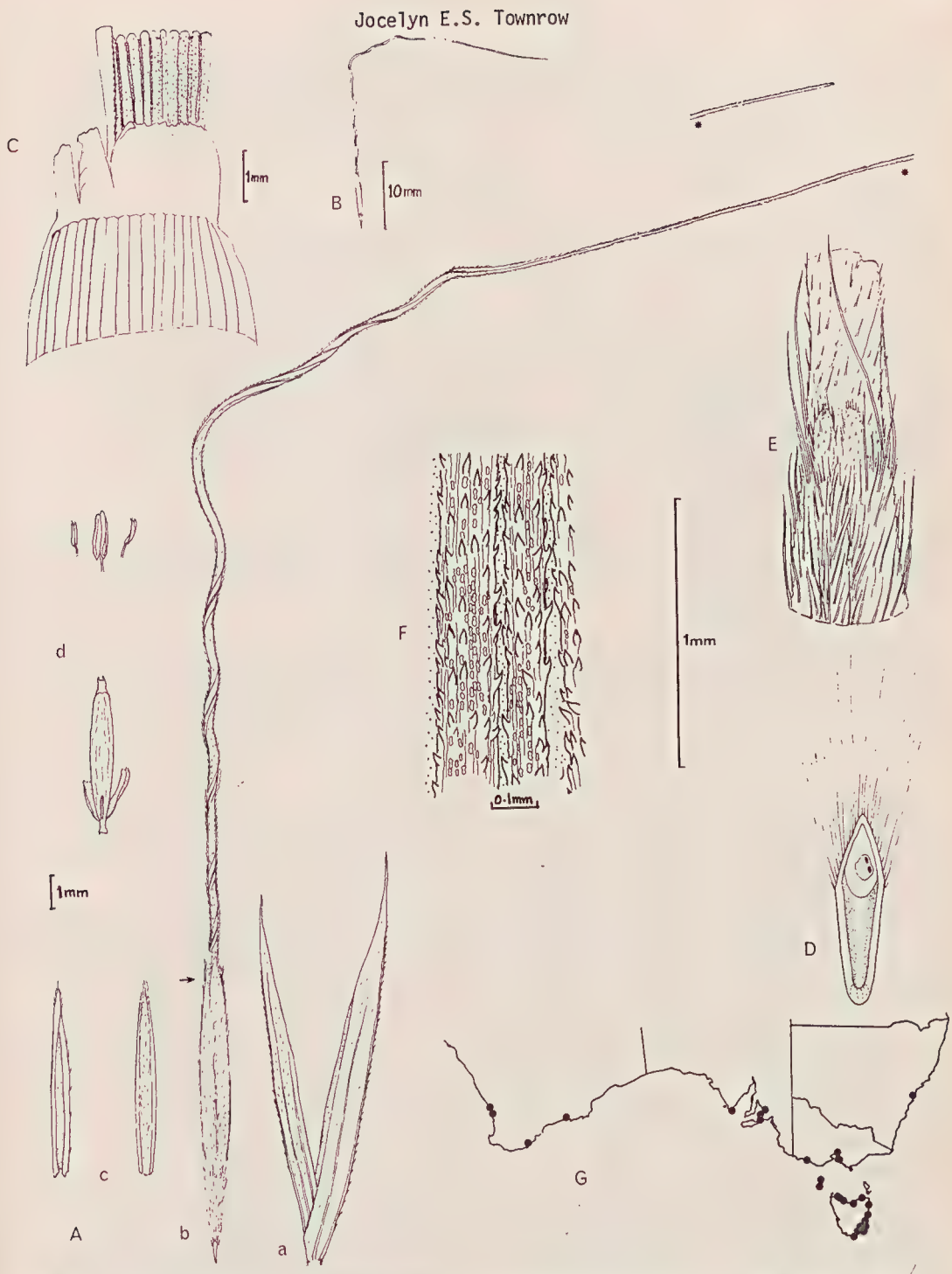

FIG. 2. - *Stipa flavescens* Labillardière, "Labillardière, Webb" (K. 35) (type specimen). Explanation as for figure 1 (p.236) except: C. Ligule (blade 2 from culm base). F. Tracing of micrograph of part of area shown in Plate 1, fig. 2.

roadside bank on north side of bridge, Dec 1967, *Townrow 94* (HO); South Arm, Opossum Bay, bank at end of road, Nov 1967, *Townrow 42* (HO). Roadside ¼ ml E of Ralphs Bay, Nov 1967, *Townrow 55, 56* (HO); Slopen Is., by old hut foundations, Dec 1967, *Townrow 83* (HO). Without definite locality: 1837, *Gunn 996* (K); *Labillardière*, Webb (K35).

Distribution: Coastal localities in Western Australia, South Australia, Victoria, New South Wales, Tasmania.

Ecology: In Tasmania, mostly in low lying coastal sandy areas, predominantly below 300m above sea level on low stabilised dunes, sandy beach ridges and sandy road verges.

Notes: 1. The great variability of this species makes identification difficult: the size of plant varies with age from one or two culms in the first year to a dozen or more inflorescences in a clump after several years; inflorescence shape varies through the flowering season from compact to open to compact; the very distinctive coppery colour of the lemmas (Munsell 5YR 3/4, dark reddish brown) is only fully developed in florets containing ripening caryopses whether they be chasmogamous or cleistogamous, and florets produced towards the base of the inflorescence or early or late in the season usually remain pale in colour. Young specimens with pale coloured florets have previous to this work been identified as *S. elatior*, (e.g. Hughes 1921, 1922).

From the limited data available cleistogamy in *S. flavescens* seems associated with floret position in the inflorescence, while lemma colour development seems associated with size of the developing caryopsis. Some specimens have both chasmogamous and cleistogamous florets e.g. *Townrow 94*, while other specimens are apparently wholly chasmogamous e.g. *Townrow 56*.

2. The A.L.S.O. of antrorse prickle hair hooks 35-50μ long, which is visible with a hand lens (x15), is a character which has proved most useful in identification of difficult specimens. Some specimens have a few macrohairs in the vicinity of the ligule, but the most usual form is without macrohairs. The hooks are much coarser than those found in *S. bigeniculata*, the only other species collected in Tasmania which has an A.L.S.O. of hooks only, in which the hooks measure 20-35μ long.

3. The type specimen (fig. 2), with cleistogamous florets, varies from the usual situation in that its ligules are hairless membranes up to 4mm instead of truncate ciliate membranes up to 0.5mm long, and its leaf blades are slightly harsher and more needle-like. *S. compacta* type specimen (fig. 2A) with chasmogamous florets is more representative of the majority of specimens.

Specimens occasionally collected have variations in ligule development. Sometimes the ligule of the older culm leaves is lopsided, one side an elongated hairless membrane up to about 3mm long, the other more normal. These specimens are frequently cleistogamous or without developing caryopses and may possibly be of hybrid origin.

4. The lamina section of *S. flavescens* as drawn by Hughes (Hughes 1921, p.19, fig. 6a) differs essentially from that of the type of *S. compacta* (*op. cit.*, p.29, fig. 31a) only in the continuous sclerenchymatous hypodermis both under and between the vascular strands. In the type of *S. compacta* the lignified tissue is not continuous under the epidermis. However, a section of the second blade from the base of the flowering culm of the type specimen of *S. flavescens* cut dry and stained in phloroglucinol shows very clearly the same distribution of sclerenchyma as that in Hughes' drawing for *S. compacta*, not as that for *S. flavescens*. In material of *S. flavescens* sclerification does increase somewhat with age. Blades lower down the culm and blades collected later in the season have a greater degree of thickening, but the hypodermal layer is never, so far as I have found, thickened in a continuous layer right round the section. It is possible that Hughes either sectioned a blade not from the type specimen (perhaps from *S. stipoides*, a species which grows in very close proximity to *S. flavescens* at

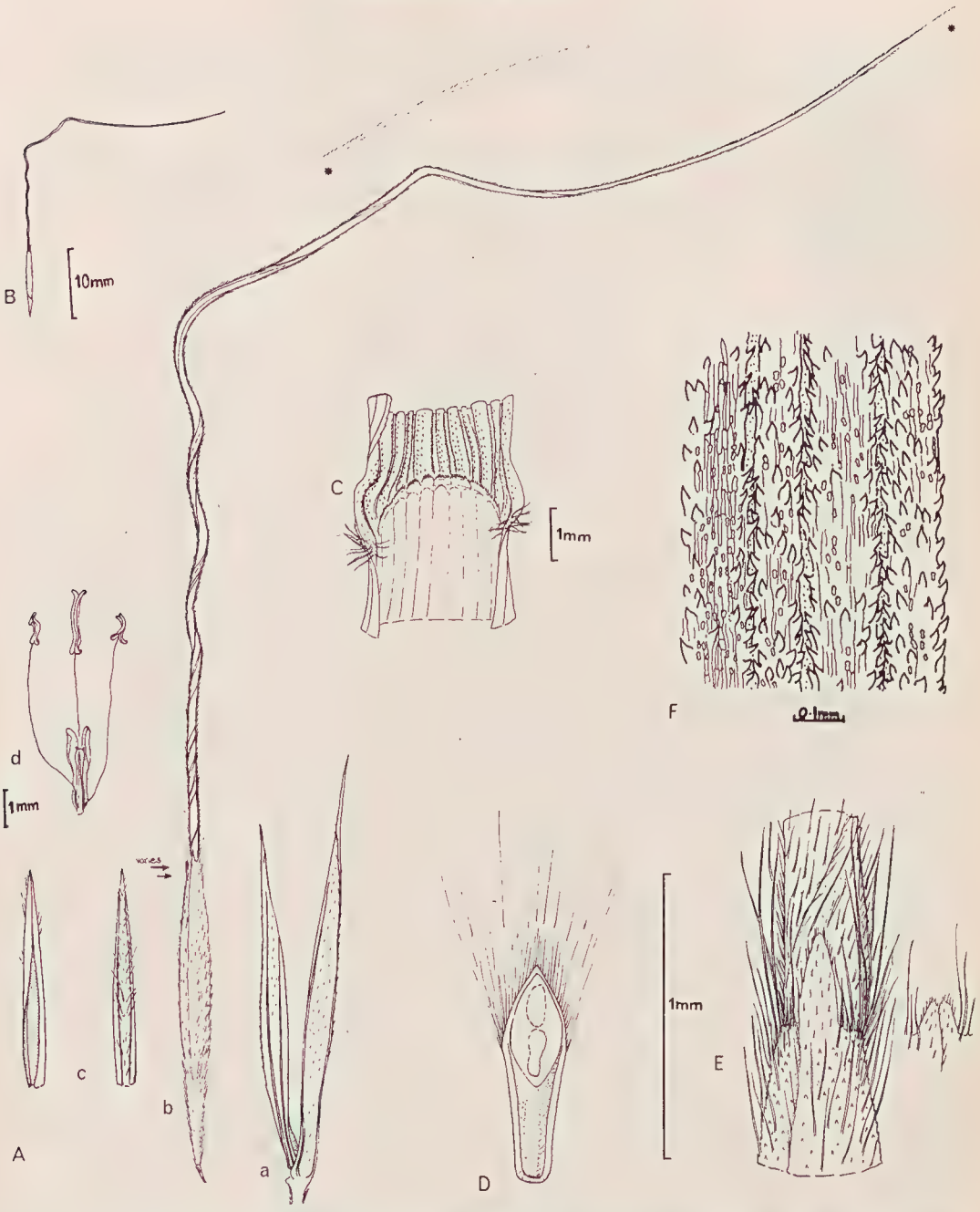

FIG. 2A. - *Stipa compacta* Hughes, (= *S. flavescens* Labillardière) "Gunn 996" (K) (type specimen). Explanation as for figure 1 (p.236) except: F. A.L.S.O. x c. 80 (tracing of scanning micrograph of "Townrow 244" (K) (matched with type specimen), blade 3 from culm base.

the present time at the type locality of the latter (see Townrow 1978), or that she misinterpreted the rather large dark epidermal cells on the abaxial side of the section as being sclerised. All leaf sections of *S. flavescens* I have examined agree with Hughes' drawing for *S. compacta*.

5. Other minor differences between the type specimens of *S. flavescens*, *S. compacta* and *S. elatior* are no more than the variations to be found in some specimens even on the one plant, and include variation in compactness of inflorescence, the presence of lemma lobes up to 0.3mm long, lemma hair colour, length of the awn to the first "knee", and the presence of ciliate sheath margins.

3. *STIPA MOLLIS* R. Brown, *Prodr.*, 174 (1810); Hughes, *Kew Bull.*, *1921*, p.18; Townrow, *Pap. Proc. R. Soc. Tasm.*, 104, p.85 (1970).
(Figure 3; Plate 1, figure 3)

Lectotype: New South Wales, Port Jackson, *Brown 6205* (K). Syn. *Stipa semibarbata* var. *mollis* (R. Brown) Bentham, *Fl. Austral.*, 7, p.569 (1878). *Stipa semibarbata* var. *gracilis* Black, *Trans. R. Soc. S. Aust.*, 67, p.36 (1943). (Lectotype: South Australia, Encounter Bay, Nov. 1930, *Cleland* (AD.97244092) [Here designated].

Short-lived perennial, robust often caespitose in open habitats, more slender in shaded places; *culms* 0.3-1.5m, up to 3.5mm diameter at base, erect, terete, 3-6 noded; *nodes densely minutely pubescent*, upper nodes exserted, pubescence white, retrorse on the lower nodes and internodes, the hairs c. 0.3mm, antrorse on the upper internodes and inflorescence axes, the hairs c. 0.1mm. *Leaf sheaths* lightly striate, becoming loose, lower sheaths minutely retrorse-pubescent especially above, outer sheath-margins smooth or minutely ciliate, orifice and collar densely bearded with fine white hairs c. 1mm; *ligule* 1-2mm, firm, ± ovate, the margin irregularly sinuate and fringed with hair, densely bearded on the back, the hairs 0.5-1.0mm; *blades* 150 - 450mm x 1.5-3.0mm wide at the base when flattened, involute, tapering with long drawn out tips, stiff and harsh, silvery green, *abaxial surface* weakly or strongly grooved, culm blades ± hairless, innovation blades minutely sparsely glandular-hairy in the grooves, *adaxial surface* deeply grooved, *densely pubescent*, *A.L.S.O.* of *very dense oval-based macrohairs 60-140 x 7-17µ diameter* at base, finely tapering, *springing out almost perpendicular to the rib surfaces, curving sharply mostly antrorsely* for c. one third length, macrohair bases 30-50µ apart, epidermal long cells c. 9µ diameter, obscured by macrohairs. *Panicle* 140-280 x c.50mm wide loosely contracted, the base later exserted, the main axis and branches minutely antrorse-scabrid, the main axis with 5-10 bearded nodes each with 3-5 slender 2-3-nate branches up to c. 70mm, the spikelets mostly towards the ends of the branches on filiform minutely scabrous pedicels 3-5mm long. *Spikelets* chasmogamous and/or cleistogamous in the same inflorescence, very pale green, soon pale straw-coloured, narrow, the glumes not widely divergent. *Glumes* subequal, lanceolate-acuminate, hyaline above, the tips very delicate and usually torn, chaffy below, margins ciliate in the type but not in Tasmanian material, very minutely hairy on and between the nerves, the microhairs c. 30µ, *lower glume* 17.4-23.0mm (when torn 14.0-19.0mm), delicately 3-nerved, *upper glume* 18.0-21.5mm (when torn 12.0-21.0mm), delicately 5-sub7-nerved. *Lemma* (6.6-) 7.1-10.5 (including callus tuft and tip) x 0.6-1.2mm wide, firm, narrowly obovate, the margins overlapping, pubescent, brown to dark brown (Munsell 10YR 3/3-4/3), the body beneath the hairs dark reddish brown (Munsell 5YR 2/2-3/3) and minutely scabrid towards the top, the hairs c. 0.75 x 0.01mm diameter at base, moderately dense, closely appressed to and curving diagonally round body, pinkish white to very pale brown (Munsell 5 YR 8/2-10YR 7/4); *callus tuft* including sharp tip 2.2-3.9mm, very pale brown to yellow (Munsell 10YR 8/3-8/6), the *callus scar* 0.40-0.60 x c. 0.07mm wide; *lemma lobes* 0.06-0.20mm, oval, minutely ciliate; *lemma crown hairs* absent, occasionally a few body hairs extend c. 0.3mm beyond awn base; *awn* once (-twice) kneed, *plumose*, the bristle curving gently from the knee, the *column* 16.5-32.0 x 0.25-0.37mm diameter above articulation and 10.0-22.0mm to first knee, the *column hairs to 2.0mm* in a double spiral, the *bristle with a single sparse*

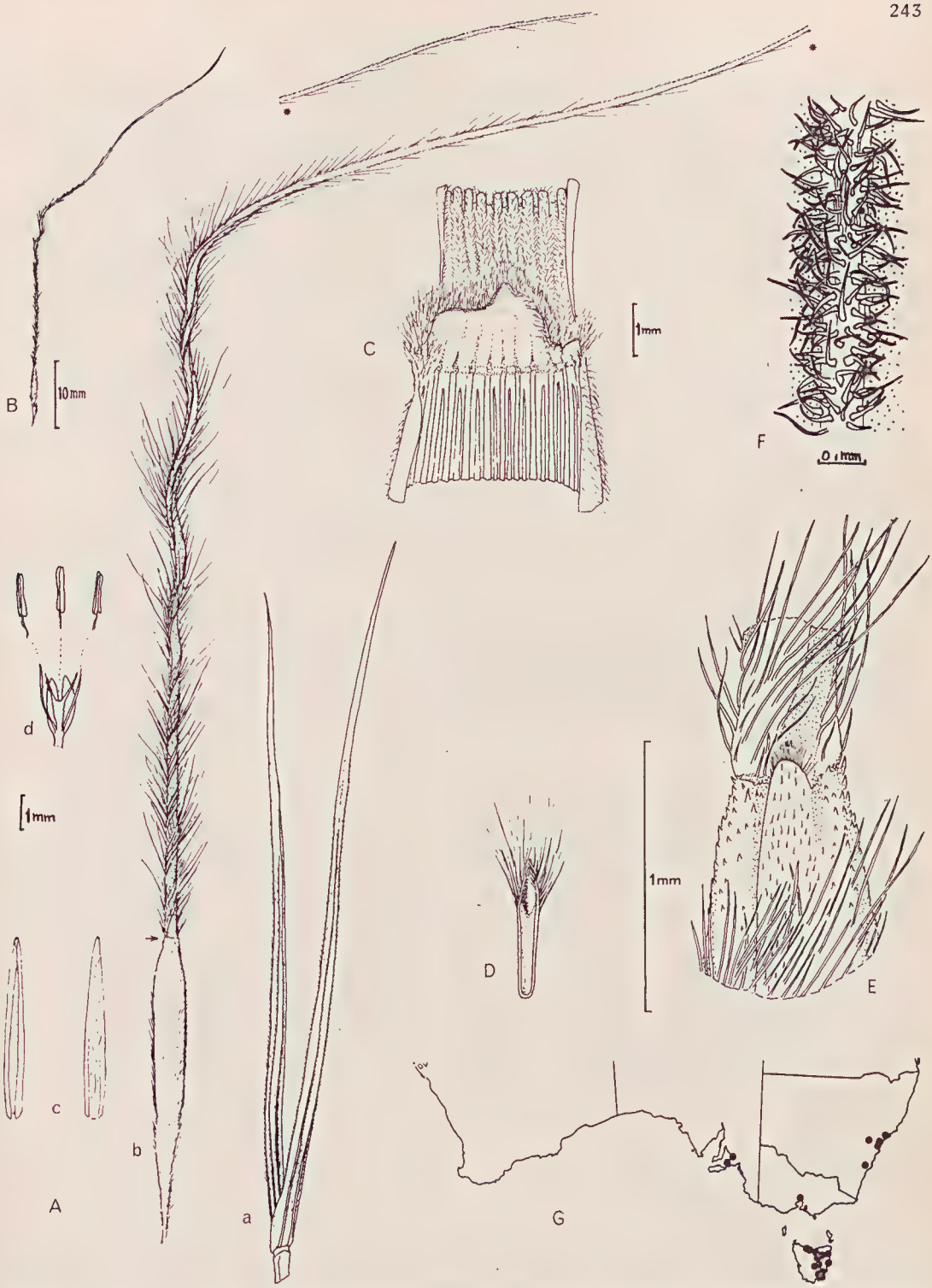

FIG. 3. - *Stipa mollis* R. Brown, "Brown 6205" (K) (type specimen). Explanation as for figure 1 (p.236) except: C. Ligule (blade 4 from top of culm *Cleland* (K.487) x 7.5. F. Tracing of micrograph of part of area shown in Plate 1, fig. 3.

row of hairs c. 1.5mm extending ± along whole length and minutely hairy on the bristle-angles. *Palea* 5.0-6.5mm, the tip hyaline reaching to top of lemma, the margins hyaline, the dorsal surface similar to the lemma in texture and hairiness between the nerves. *Anthers* usually 1 larger + 2 smaller, rarely 1 smaller + 2 larger; in chasmogamous florets the larger (3.2-)3.4-4.7mm, the smaller (2.6-)3.2-4.6mm; in cleistogamous florets the larger 1.1-2.5mm, the smaller 0.6-1.8mm. *Lodicules* two large anterior c. 1.5mm, with or without a minute delicate membrane c. 0.5mm in posterior position.

SOUTH AUSTRALIA. - Flinders Ranges: Wilpena Pound, Nov 1930, *Cleland H98* (K). Southern Lofty: Pinery near Grange, *? Cleland H.487* (K); Grange near Adelaide, Oct 1927, *Cleland 72* (K); National Park, Belair, Nov 1932, *Cleland* (AD 97244903); Happy Valley, Nov 1926, *Cleland* (K); Compass Mt., Oct 1920, *Cleland* (K); Bach Valley, Encounter Bay, Nov 1930, *Cleland H61* (K), (AD 97244092). Kangaroo Is.: Vivonne Bay, Nov 1924, *Cleland* (AD 97244091).

NEW SOUTH WALES. - Western district (?): Franco-British Exhibition, exhib. by Director Bot. Gdns. Sydney (K). Southern Tablelands: Summit area of Mt. Budawang, E of Braidwood, Dec 1965, *Pullen 4126* (K, ex. CANB). Central Tablelands: Lithgow, Jan 1936, *Vickery* (NSW). Central Coast: Maroubra, frequent in seacliff scrub, Oct 1946, *Johnson* (NSW); Tempe District, Oct 1899, *Boorman* (K431, NSW); Port Jackson District, auf sandhügeler unweit Sydney, Oct 1900, *Meersnäke* (K), Port Jackson, *Brown 6205* (K, BM); South Coast: Bowen Is., Jervis Bay, Dec 1931, *Rodway* (K, ex NSW 662).

VICTORIA. - Eastern Highlands: Wendu [? Wando] Vale, forestland, Nov 1843, *Robertson 529* (K). Central[Melbourne]: Ringwood, (2 sheets), Oct 1929, *Sonenberg* (K), Sheet 2, Oct 1891, *Morrison* (K); Port Phillip Bay, Ricketts Point, Nov 1935, *Sonenberg* (K).

TASMANIA. - North: Cressy, Nov 1948, *Moore* (CANB); Cataract Gorge, South Esk River, on rocky cliffs, Oct 1943, *Curtis* (K); Launceston, Nov 1912, *Cleland* (NSW). South East: Domain, Jan 1895, *Rodway* (HO); Hobart Town, *Gunn 1452* (K, HO); University of Tasmania, roadside bank by Agric. Science Glasshouse, Jan 1970, *Townrow* (HO); Blackmans Bay: Sandy heath, Jan 1945, *Curtis 22*(K), Sandy hillside, Jan 1947, *Curtis* (K); North Bruny Island, Roadside, Dennes Point road at second steep corner opposite the "Iron Pot" travelling N from Barnes Bay, Jan 1968, *Townrow 139* (HO), Great Bay, roadside through wooded area at N end, Jan 1970, *243* (K), Variety Bay, Cape Queen Elizabeth track at turn off to ruined homestead, Jan 1968, *158* (HO). North East: Bridport, road to Entally, Nov 1952, *Curtis* (HO), Cliff top, Nov 1952, *Curtis* (HO); Waterhouse Estate, stabilised dune slack, Dec 1967, *Townrow 110* (HO); St. Helens, track to flagstaff, on dry hillside, Nov 1945, *Curtis* (K); East Coast roadside, nine km S of St. Helens, Jan 1968, *Townrow 187* (HO). East: Risdon, Jan 1949, *Vickery* (K, HO, NSW 7492); Road to South Arm (Goat Hill) near Hobart, Dec 1946, *Curtis* (K); two km N of Ralphs Bay, open eucalypt woodland, Nov 1967, *Townrow 57* (HO); three km S of Richmond on Cambridge road, Nov 1967, *Townrow 75* (HO); Road to Port Arthur between mileposts 39 and 40, Nov 1966, *Townrow 9* (HO); Runnymede Post Office, roadside, Nov 1967, *Townrow 63*(HO); Slopen Island, very open sandy ground at edge of eucalypt scrub, Dec 1967, *Townrow 81* (HO), East side, Dec 1967, *82* (HO); Eaglehawk Neck, Nov 1951, *Curtis* (HO); Beside Prosser River, Steep, rocky bank 4.3 km W of Orford, Nov 1967, *Townrow 70* (HO), Rough hillside 3.4 km W of Orford, Nov 1967, *71* (HO); Orford, roadside 1.2 km N of camping ground, Jan 1968, *Townrow 171* (HO); Coles Bay 10 km N of Ranger's house, Jan 1968, *Townrow 180* (HO).

Distribution: South-eastern states of Australia; eastern half of Tasmania.

Ecology: In Tasmania, lightly shaded wooded areas mostly below 300m above sea level with annual rainfall below 1140mm.

Notes: 1. *Stipa mollis*, and *S. semibarbata* R. Br. with which it is much confused, belong to a complex which on the Australian mainland also includes *S. plagiopogon* Black, *S. densiflora* Hughes, *S. hemipogon* Bentham, and *S. nobilis* Pilger. This complex

needs much further detailed taxonomic investigation before the existing chaos can be unravelled.

2. Localities recorded on herbarium sheets of specimens, clearly either *S. mollis* or *S. semibarbata*, indicate that both grow in the south-eastern states of Australia, but only the latter occurs in south-western Australia (fig. 3G, fig. 4G). In Tasmania where most populations can be ascribed to one or other species on the basis of awn hair character (*S. mollis* hairs c. 2.0mm, continuing along the bristle ± to end; *S. semibarbata* hairs c. 1.0mm on the column only; fig. 3Ab, fig. 4Ab), and A.L.S.O. (fig. 3F, fig. 4F), the complex occurs almost exclusively in the eastern half of the island. (see Townrow 1974, p.24).

3. Bentham (1878) and Willis (1962) regard *S. mollis* as a more robust, more hairy form of *S. semibarbata* although the type specimens (*S. mollis*, Port Jackson, *Brown 6205*, fig. 3; *S. semibarbata*, Port Dalrymple, *Brown 6204* [the figured specimen *Townrow 248*, fig. 4, closely matches *6204*]) can be differentiated on lemma dimensions, the shape and hair ornamentation of the glume nerves, the A.L.S.O., the number and development of anthers and lodicules, and the mode of leaf blade venation.

4. The three specimens of *S. semibarbata* var. *gracilis* designated by Black (1943) as types, have lemmas which are quite distinct from those of the type of *S. semibarbata*. Whereas the latter is characterised by lemmas with awn columns 26.0-30.5mm to the first knee with hairs 0.3-1.6mm long, and bristles with only minute dense hairs about 0.1mm long, the three type specimens of *S. semibarbata* var. *gracilis* have awn columns 10-13mm to the first knee with hairs up to 2mm long. They are therefore much closer to the type of *S. mollis* and differ from it only in minor characters of indumentum and dimension, coming well within the range of variation of *S. mollis* as it is represented in Tasmania. The lectotype of *S. semibarbata* var. *gracilis* which has not previously been published as such, was selected from the three designated specimens, as it is the one most distinct from *S. mollis*. It has awn hairs about 1.6mm long which do not extend beyond the top of the column. In both the other specimens the awn bristles bear a few long hairs almost to the tip as do those of *S. mollis*.

5. Morphologically intermediate forms occur in several areas of distribution-overlap where *S. mollis* and *S. semibarbata* exist in close proximity, (e.g. 14 km and 5 km west of Bothwell on the Bothwell/Ouse road, on North Bruny Is. at Dennes Point and on Maria Is., Chinamans Bay, "Neck" region. This suggests that an incomplete genetic barrier exists. Either the taxa are distinct but have some degree of sympatric introgression, or they belong to two partially differentiated and isolated sets of populations of the same taxon.

The range of variation in spikelet dimensions of five specimens selected for *S. mollis* and *S. semibarbata*, separated on the basis of awn hair character and A.L.S.O., shows substantial overlap in all characters except callus scar dimensions and length of the awn column, with a tendency in most characters towards larger dimensions in *S. semibarbata*. Numerical taxonomic treatment together with evidence from cytological investigations could be used to determine whether the taxa are discrete entities or belong to a variable continuum. So far it is known that some specimens of *S. mollis* have reduced pollen fertility whereas none has been observed in *S. semibarbata*. Cleistogamy has been observed in specimens of both taxa. A proper investigation of the breeding systems and reproductive capacities of the two sets of populations would clarify the existing relationships. Further research is necessary, but in Tasmania at least, it is useful to maintain *S. mollis* and *S. semibarbata* as separate taxa, because each occupies a distinct although overlapping ecological niche. *S. mollis* is more closely associated with shaded wooded areas, and seems adapted to cooler summer and warmer winter temperatures than *S. semibarbata*. *S. semibarbata* is more associated with open areas in woodland and scrub (see Townrow 1974, p.25).

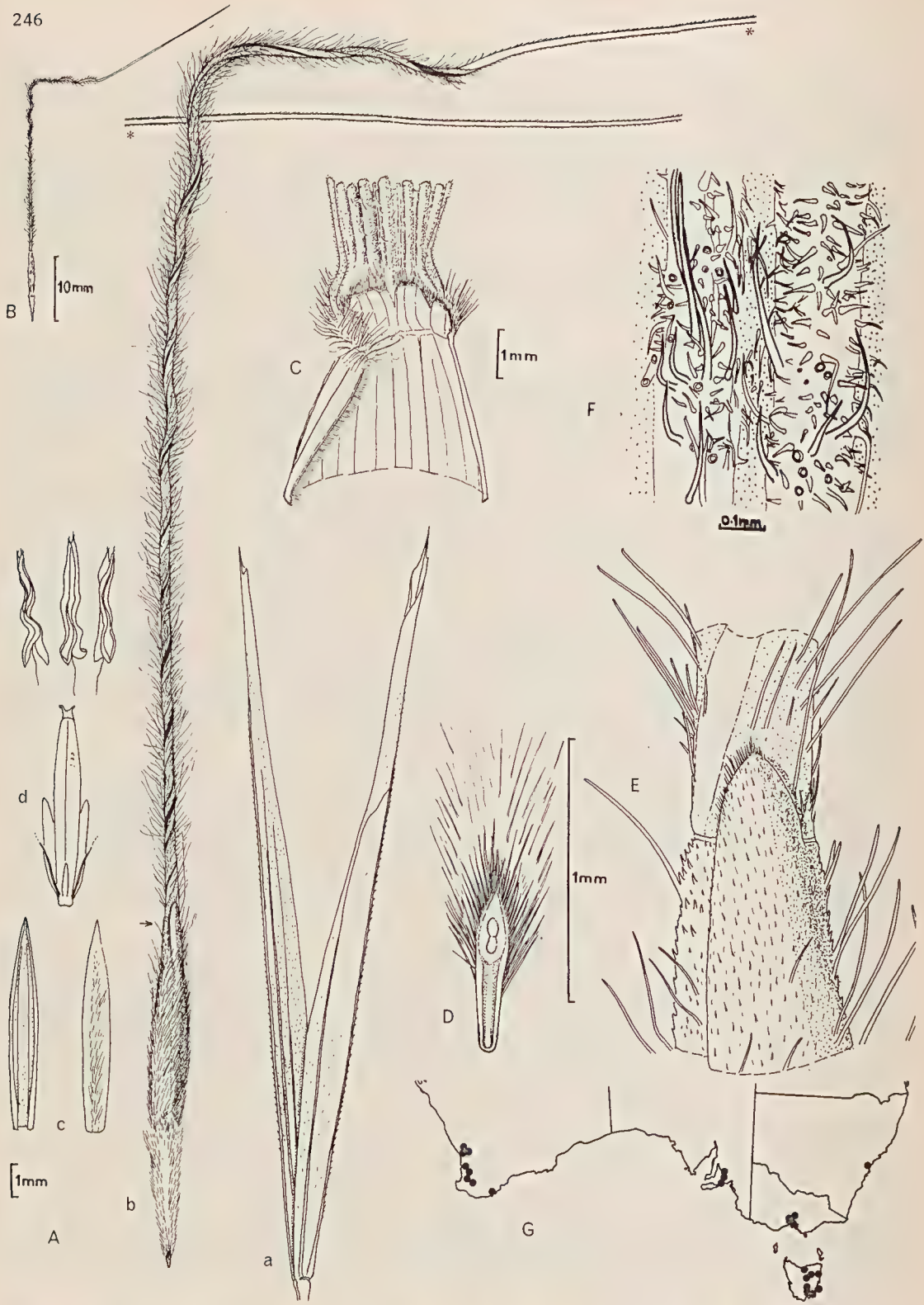

FIG. 4. - *Stipa semibarbata* R. Brown, "Townrow 248" (K) (matched with type specimen). Explanation as for figure 1 (p.236) except: C. Ligule (blade 2 from culm base); F. Tracing of micrograph of part of area shown in Plate 1, fig. 4.

4. *STIPA SEMIBARBATA* R. Brown, *Prodr.*, 174 (1810); Hughes, *Kew Bull.*, *1921*, p.20 (1921); Townrow, *Pap. Proc. R. Soc. Tasm.*, 104, p.86 (1970).
(Figure 4; Plate 1, figure 4)
Lectotype: Tasmania, Port Dalrymple, *Brown 6204* (BM).

Short-lived perennial, robust, caespitose; *culms* 0.3-1.5m, 2.0-5.0mm diameter at base, erect, terete, 3-5 noded; *nodes* ± exserted, densely finely retrorse pubescent with a felt of white hairs c. 0.1mm (occasionally to 1.0mm) extending c. 2mm below the nodes, the internodes smooth or minutely pubescent, the hairs c. 0.05mm, retrorse on the lower internodes and antrorse on the upper internodes and inflorescence axes. *Leaf sheaths* lightly striate, becoming loose, minutely retrorse-pubescent below becoming ± smooth or minutely scaberulous above, outer sheath-margins shortly ciliate at least towards the orifice, orifice and collar densely bearded with fine white hairs 0.5-1.0mm; *ligule* 1-2(-4)mm, firm, ± ovate, the margin irregularly sinuate and fringed with hair, densely bearded on the back, the hairs 0.1-0.4mm; *blades* 150-350 x 2.0-4.0mm wide at the base when flattened, convolute, tapering with long drawn out tips, stiff and harsh, light green, *abaxial surface* weakly striate, culm blades minutely retrorse-hairy in the shallow grooves towards the collar, smooth and hairless above, innovation blades sparsely minutely antrorse- or retrorse-scabrous, *adaxial surface* deeply grooved, sparsely hirsute, *A.L.S.O.* of *moderately dense somewhat coarse macrohairs and frequent peg-like prickle hairs*, the macrohairs mostly *antrorse or ascending*, 30-320 x 7-21μ diameter at base with a basal collar, the prickle hairs 10-14 x 10-14μ diameter at base, mostly blunt tipped, some pointed, arising perpendicular to the rib surfaces then curving retrorsely or antrorsely, epidermal long cells c. 7μ diameter with sinuous walls. *Panicle* 140-350 x c. 20(100)mm loosely contracted, the base later exserted, the main axis and branches minutely antrorse-scabro-pubescent, the main axis with 5-8 nodes each, with 3-5 slender 2-3-nate branches up to c. 70mm the spikelets mostly towards the ends of the branches on filiform minutely scabro - pubescent pedicels up to 150mm long. *Spikelets* chasmogamous or cleistogamous, very pale green, soon straw coloured, narrow, the glumes diverging at c. 30°. *Glumes* subequal, linear attenuate, hyaline above, the tips delicate and usually torn, chaffy below, minutely hairy between the nerves, minutely scabrous with prickle-hairs on the nerves, *lower glume* 19.5-24.2 mm (when torn 16.5-19.5mm), clearly 3-nerved, *upper glume* 17.5-20.0mm (when torn 14.0-17.5mm), clearly 5-nerved. *Lemma* 9.0-11.4 (-11.8) (including callus tuft and tip) x 0.7-1.2mm wide, firm, narrowly obovate, the margins overlapping, pubescent, very dark greyish brown (Munsell 10YR 3/2), the body beneath the hairs very dark brown (Munsell 10YR 2/2) and densely minutely scabrid in the upper hairless part, minutely pimpled under the hairs to half way down, the hairs c. 0.64 x 0.01mm diameter at base, moderately to very dense, closely appressed to and curving round body at c. 15° to vertical, white (Munsell 10YR 8/2); *callus tuft* including sharp tip 3.2-4.5mm, white (Munsell 10YR 8/1), the *callus scar* 0.60-0.67 x c. 0.13mm wide; *lemma lobes* absent or 0.05-0.17 mm, ciliate, the hairs up to 0.12 (-0.25)mm; *lemma crown hairs* absent, or in two lateral tufts each of 1-6 uneven hairs exceeding awn base by 0.2-0.5mm; *awn twice kneed, shortly plumose to the second knee*, the *column* (30.0-) 32.0-42.5 x 0.27-0.45 (-0.50)mm diameter above articulation and 20.0-30.5mm to first knee, the *column hairs 0.3-1.6mm over the whole length of the column*, the *bristle without long hairs but with minute dense hairs c. 0.1mm* on the bristle-angles. *Palea* (6.1-) 6.3-7.8mm, the tip hyaline, reaching to top of lemma or down to 0.5mm below top of lemma, the margins hyaline, the dorsal surface as hard and hairy as the lemma. *Anthers* equal in length, or 2 larger + 1 smaller, or 2 smaller + 1 larger; in chasmogamous florets the larger 2.9-6.1mm, the smaller 2.6-6.0, or if equal c. 6.0mm; in cleistogamous florets the larger 1.3-1.9mm, the smaller 1.0-1.8mm, or if equal 1.1-2.0mm. *Lodicules* three, the two anterior large, c. 3.0mm, the posterior a delicate membrane c. 1.0mm.

WESTERN AUSTRALIA. - Darling: Bullsbrook, 1930, *Palmer* (K); Swan River, Herb. Hooker 1867 (K); Leederville, 2 sheets, recd. 18.4.1916, *Steward 935* (K); Kelmscott, Sept 1924, *Carne* (K); Harvey [2 specimens], Oct 1932, *Davies* (K); Araluen, Darling Range, Dec 1951, *Burbidge 13641* (CANB 26696); Three miles W of Mayanup, Sept 1947,

Burbidge 2551 (CANB 15827); Kojonup, "Glen Lossie", Sept 1947, *Burbidge 2517* (K); Bridgetown to Kojonup and Slab Hut Gully, 1910, *Dorrien Smith* (K).

SOUTH AUSTRALIA. - Southern Lofty: Belair, Oct 1902, *Koch* (K); Aldgate, Nov 1913, *Cleland S.25* (K); Mylor (3 sheets), Nov 1930, *Bailey* (K); Mount Lofty, Dec 1947, *Burbidge* (CANB 16575); Mount Lofty Bot. Garden, c. 12km SE of Adelaide, Dec 1963, *Kuchel 1494* (K); Mount Lofty Range, Sterling West, c. 15km SE of Adelaide, Dec 1960, *Ising* (K. AD); Compass Mt., Oct 1920, *Cleland S4* (K); Kuitpo, Nov 1912, *Cleland* (K426), Nov 1922, (2 sheets), *S18* (K); Basket Range, Nov 1930, *Bailey* (K).

NEW SOUTH WALES. - Central Coast: Bondi, Oct 1912, *Blakely* (K428).

VICTORIA. - Central [Melbourne]: Studley Park, Oct 1958, *Muir 519* (NSW); Colony of Victoria (2 sheets), Sept-Dec 1854, *Harvey* (K); *Muir 1956* (MELB); Rickets Point, Nov 1935, *Sonenberg* (K). Eastern Coastal Plains: Gippsland, *Campbell* (K).

TASMANIA. - North East: Penquite (SE Launceston), Dec 1845, *Gunn 1480* (K); Port Dalrymple, *Brown 6204* (BM). South East: Dromedary, Jan 1895, *Rodway* (HO); Domain, Nov 1928, *Rodway* (HO); Alluvial gravel bank, roadside opposite Agric. Science Dept. Glasshouse, Univ. of Tasmania, Jan 1970, *Townrow 248* (K); Shallow soil on hill above Derwent Estuary, Jan 1949, *Burbidge 3184* (HO, CANB); Sorell/Orford road, rest area 10km N of Sorell, Jan 1968, *Townrow 166* (HO), Millar's Causeway, 16km N of Orford campsite, Jan 1968, *Townrow 175* (HO).

Distribution: South western and south eastern states of Australia; eastern half of Tasmania.

Ecology: In Tasmania, open areas in woodland and scrub below 300m with annual rainfall below 1140mm.

Notes: 1. It proved possible to make only a superficial study of the lectotype at the British Museum because of the mounting technique employed and the inadequacy of equipment provided for examination of specimens. The whole plant was pasted to the sheet and many diagnostic features were obscured. The specimen drawn in fig. 4 (*Townrow 248* (K, HO)) closely matches the type specimen except that the lemmas are slightly shorter (10.7mm instead of 11.0mm) and the awn column to the first knee measures 1mm less than in the type.

2. Further notes on *S. semibarbata* are included in the discussion on *S. mollis*.

5. *STIPA NERVOSA* var. *NEUTRALIS* Vickery, *Contrib. N.S.W. natl Herb.*, 1(6), p.337 (1950); Townrow, *Pap. Proc. R. Soc. Tasm.*, 104, p.86 (1970).
(Figure 5; Plate 1, figure 5)

Holotype: New South Wales, Katoomba, 22 Dec 1939, *Blake 13915* (NSW 8569).

Perennial, robust, erect, caespitose; *culms up to 1.2(-1.8)m high*, rigid, stout, up to 4mm in diameter, lightly striate, smooth, glabrous, 3-4-noded, the uppermost node often exserted at flowering; *nodes* finely retrorse pubescent with a felt of minute white hairs. *Leaf sheaths* slightly striate, scaberulous in the grooves, glabrous but pubescent round the back of the orifice, the outer margins sometimes ciliate, light green; *ligule* up to 1.3mm, firm, truncate, minutely ciliolate, pubescent on the back, the hairs extending c. 0.3mm beyond marginal cilia; *blades* up to c. *400 x 3-5mm wide* at the base when flattened, involute, with long, tapering, curving tips, dark green, *abaxial surface* hardly grooved, sparsely recurved-hairy, the hairs c. 0.8mm, *adaxial surface* deeply grooved, scabro - pubescent, *A.L.S.O. coarse, moderately dense ± ascending macrohairs* and *frequent to abundant slightly antrorse prickle hair hooks*, the macrohairs 70-450 (-600) x 14-28 (-40)μ diameter at base, finely tapering with *swollen often humped bases* bending at about 45° to ribs, and basal collars, the prickle hair hooks 20-40 x 14-21μ diameter at base, epidermal long cells 35-70 x 10-15μ wide with "withy basket" appearance. *Panicle* 200-400mm, very lax,

FIG. 5. - *Stipa nervosa* var. *neutralis* Vickery, "Burbidge 2935" (K) (matched with type specimen). Explanation as for figure 1 (p.236) except: C. Ligule (blade 3 from culm base). F. Tracing of micrograph of part of area shown in Plate 1, fig. 5.

spreading, loosely contracted when dry, the base included in uppermost sheath in early stages of flowering but later exserted, the main rachis slightly scabrous, with very slender branches arising from 4-5 nodes, the branches several times divided with spikelets mostly towards the ends of the branchlets, the pedicels 2-15mm. *Spikelets* chasmogamous and/or cleistogamous in the same inflorescence, pale green to maroon below and straw coloured above, with somewhat divergent glumes. *Glumes* thin, chaffy, with hyaline, usually torn tips, narrow, linear attenuate, the lateral nerves as strong as the mid nerves, nerves minutely scabrid on backs, *lower glume* 11.1-13.0+ (when torn 10.0-13.0)mm, conspicuously 3-nerved, *upper glume* 10.0-13.0+ (when torn 8.5-13.1)mm, conspicuously 5-nerved. *Lemma* 8.1-11.0 (including callus and tip) x 0.7-1.1mm wide, firm, linear, the body reddish brown to very dusky red at maturity (Munsell 5YR 4/4 to 2.5YR 2/2) with sparse vertically appressed hairs on lower three quarters of length, the hairs in chasmogamous florets white (Munsell 2.5Y 8/0), and in cleistogamous florets yellow (fulvous) (Munsell 2.5Y 8/6), c. 0.7 x 0.02mm diameter at base, lemma margins overlapping, upper one quarter of surface (above the hairs) minutely hooked, lower three quarters papillose beneath hairs, the papillae diminishing towards the callus tuft; *callus tuft* including sharp tip (2.1-) 2.3-3.0mm, yellow (Munsell 2.5Y 8/4 - 8/6), the *callus scar* 0.50-0.62 x c. 0.18mm wide; *lemma lobes* absent; *lemma crown hairs* absent; *awn* twice kneed, moderately densely minutely hairy over entire length, the hairs on the column c. 0.12mm at c. 25° to awn surface, the *column* 30.0-46.0 x 0.37-0.46mm diameter above articulation (which is itself c. 0.51mm diameter) and 20.0-36.0mm to first knee. *Palea* 6.0-8.0 (-8.3)mm, the tip hyaline reaching to c. 0.5 mm below top of lemma, slightly less horny than lemma, dorsal surface with very few minute hairs above between the nerves. *Anthers* usually 1 larger plus 2 smaller, rarely equal; in chasmogamous florets the larger (1.1-) 2.2-5.6mm, the smaller (0.9-) 1.5-5.3mm, in cleistogamous florets the larger 1.1-2.2mm, the smaller 0.6-1.7mm. *Lodicules* three, c. 2.0mm, the two anterior swollen and the posterior very thin, delicate and hyaline.

QUEENSLAND. - Darling Downs: Grazing bush, Bedford's place nr. Wyberba, Nov 1944, *Clemens 44760* (K); Wyberba, 2500-3000ft, among acid rocks in mixed open forest, Jan 1933, *Blake 4638* (K).

NEW SOUTH WALES. - Central Tablelands: Katoomba, Dec 1939, *Blake 13915* NSW 8569). Central Coast: Milperra, Georges R., Sheet 2, Oct 1930, *Vickery* (K). South Coast: Ulladulla, 67km S of Nowra, Dec 1932, *Rodway* (K, NSW 1005).

VICTORIA. - Eastern Highlands: Christmas Hills, 40km NE of Melbourne, *Aston*(MEL). Eastern Coastal Plains: Orbost, ex herbarium Beauglehole 7955, Nov 1937 *Robbins*(NSW).

TASMANIA. - North: Devonport, Feb 1948, *Curtis 131* (K); Roadside 10km E of Launceston, Jan 1949, *Burbidge Herb. Austral. 2935* (K.CANB.HO.); Roadside 1km E of O'Connors Peak/Campbelltown road junction, Dec 1967, *Townrow 124* (HO); Evandale, beside South Esk bridge, Dec 1967, *Townrow 114* (HO). Central Plateau: Near Derwent Bridge (Bronte), Jan 1949, *Burbidge 3390* (CANB). South East: Dromedary, Jan 1895, *Rodway* (HO); Domain, roadside parallel to Brooker Highway, Oct 1966, *Townrow 3* (HO); Kingston, Junction of main road with Lesleyvale road, Jan 1968, *Townrow 165* (HO), Feb 1932, Sheets 1, 2 and 3, *White 8336* (K); N Bruny Is, Dennes Point road, second steep corner opposite Iron Pot (facing N), Jan 1968, *Townrow 137* (HO), Roadside N side of Bull Bay, Dennes Point road, Dec 1966, *18a* (HO), Roadside, steep corner 1km S of Quarantine Station, Jan 1968, *181* (HO); Barnes Bay, Mar 1967, *Townrow 19* (HO); Roadside, Great Bay, Jan 1970, *Townrow 245* (K). East: Lindisfarne/Risdon Road, dry hillside above Bus Stop 18, Dec 1967, *Townrow 91* (HO); Richmond/Cambridge road, roadside 5km S of Richmond, Nov 1967, *Townrow 76* (HO); Pittwater, Jan 1926, *Black 1193* (K); Dunalley/Copping roadside, 5km W of Dunalley Bridge, Dec 1967, *Townrow 104* (HO), 1.5km W of Dunalley Bridge, Dec 1967, *Townrow 103* (HO); East Coast, in dry bush between Cape Bernier and Cockle Bay, Jan 1945, *Curtis 18A* (K). North East: Fingal Valley, about 2km E of Tullochgorum, roadside, Feb 1968, *Townrow 196* (HO); Mathinna, c. 270m, Jan 1962, *Phillips* and *Vickery* (CBG 001268); 3km E of Mathinna, roadside, Feb 1968, *Townrow 197* (HO).

Distribution: Central and Southern Victoria, eastern half of Tasmania.

Ecology: In Tasmania, roadsides in cleared areas near the east coast between altitudes of 30-180m with annual rainfall below 1140mm.

Notes: 1. *S. nervosa* var. *neutralis* has been confused with *S. pubinodis* (fig. 6) (wrongly identified as *S. pubescens* R.Br.) in Tasmania, and with *S. pubescens* (Appendix 3B; Plate 2, fig.B) on the Australian mainland. It may be most easily distinguished from these species by means of its ligule, and the very characteristic A.L.S.O. of coarse swollen-based hairs, teeth and hooks, which differs markedly from the dense fine hairs of *S. pubinodis* and the very fine teeth of *S. pubescens*.

2. Evidence exists of association between fulvous lemma hair colour and cleistogamy. Chasmogamous florets appear to retain the white lemma hair colouration typical of the early flowering stages whereas cleistogamous florets may be white or fulvous haired, e.g. *Townrow 18a* has both cleistogamous (fulvous-haired) and chasmogamous (white haired) florets; *Townrow 181* has only cleistogamous florets, some white haired (lower down the inflorescence, so younger) and some fulvous haired; *Townrow 19* and *137*, both cleistogamous with white lemma hairs, might have been expected to develop fulvous colouration as the caryopsis developed to full size (c. 5.5mm). An alternative possibility is that the development of fulvous colouration is associated with a *fully developed* caryopsis whether the floret be chasmogamous or cleistogamous. Chasmogamous material with fully developed caryopses has yet to be collected.

6. *STIPA PUBINODIS* Trinius and Ruprecht, *Mém. Acad. Sci. St. Petersb.* sér. 6, *Sci. Nat.* 5 (1), p.50 (1843) preprinted as *Species Graminum Stipaceorum (Gramina Agrostidea. III. Callus obconicus (Stipacea)*, etc.) Petropoli (1842); Hughes, *Kew Bull., 1921.* p. 28 (1921); Townrow, *Pap. Proc. R. Soc. Tasm.*, 104, p. 86 (1970) (as *"S. pubescens"*).
(Figure 6; Plate 1, figure 6)
Holotype: Terra Van Dieman labelled "V.D.L.11" (LE).

Short-lived perennial, caespitose in open habitats, less robust in shaded places; *culms* up to c. 1.1m, up to 4mm diameter at base, rigid, terete, 3-(5) noded; exserted upper *nodes*, minutely velvety retrorse pubescent towards the inflorescence, otherwise smooth. *Leaf sheaths* finely striate, densely minutely retrorse-pubescent on the striae towards the nodes, ± smooth above, outer sheath margins minutely ciliate or smooth, upper sheaths shortly bearded in the auricle position and round the collar; *ligule*, lower ligules 1.5-2.0(-4.0)mm, *firm, rotund-obtuse, sometimes lopsided*, very minutely hairy on the backs, upper ligules shorter, truncate, with hairy backs and margins, the hairs c. 0.07mm; *blades* 150-500 x 1.0-2.5mm wide at the base when flattened, convolute, filiform, fairly stiff, dark green, somewhat silvery below, *abaxial surface* hardly grooved, the lower blades and innovations moderately densely antrorse-(rarely retrorse) hairy, the hairs up to c. 0.2 x 0.02mm diameter at base, the upper blades smooth, *adaxial surface* deeply grooved, *moderately densely minutely shaggy-pubescent*, *A.L.S.O.* of moderately dense, strongly antrorse-ascending, finely tapering macrohairs and frequent prickle hairs, the macrohairs on the lower blades 70-280 x 10-15µ diameter at base, becoming shorter and finer on successive blades up the culm, the prickle hairs 20-43 x 10µ diameter at base, antrorse on the outer rib surfaces, vertical on the surfaces between the ribs, some straightsided, some slightly antrorsely curved, epidermal long cells 35-57 x 10-15µ wide with "withy basket" appearance. *Panicle* 150-260mm, slightly contracted, the base long exserted from uppermost sheath at flowering, the main rachis with up to 6 minutely bearded nodes, the lower nodes c. 40mm apart with 6-10 slightly scabrid 1-2(-3)-nate slender branches up to 6.0(7.5)cm each bearing 3-4(-5) spikelets towards the ends on filiform minutely scabro-pubescent pedicels 3-20mm long. *Spikelets* chasmogamous or cleistogamous, very pale green, soon straw coloured, narrow, the glumes not widely divergent. *Glumes* unequal, chaffy below, hyaline above, the tips delicate and usually torn, very minutely sparsely hairy between

FIG. 6. - *Stipa pubinodis* Trinius and Ruprecht, '1. "Gunn 588" (K) (type specimen). '2. "Townrow 247" (HO) (matched with type specimen). '3. "Flowering specimen cultivated at University of Tasmania, Oct. 1970 (matched with type specimen). Spikelet characters:- A. a. glumes (specimen '1.); b. lemma (specimen '2.); d. lodicules, anthers, ovary (specimen '3.)x 5. B. Lemma x1 (Specimen '1.) D. Callus scar x40 (Specimen '1.). E. Lemma lobes x40 (Specimen '1.) Leaf characters:- C. Ligule (blade 2 from culm base x7.5 (Specimen '1.). F. A.L.S.O. x c.80 (tracing of micrograph of part of area shown in Plate 1, fig. 6). G. Species distribution (Cited specimens) H. Longitudinal section of embryo (specimen '3, 1976).

the nerves, *lower glume* 20.0-25.0mm (when torn 15.0-23.0mm), clearly 3-nerved, *upper glume* 16.0-20.9+mm (when torn 14.0-20.9mm) clearly 5-nerved. *Lemma* 11.0-13.0 (including callus tuft and tip) x 0.7-1.1mm wide, firm, linear, the margins overlapping, densely hairy below and sparsely hairy above, dark yellowish brown (Munsell 10YR 3/4), the body dark reddish brown (Munsell 5YR 2/2) and minutely dentate over the upper one third, the barbs c. 0.03mm moderately dense and irregularly spaced, the hairs c. 0.90x 0.02mm diameter at base, vertically appressed, white becoming reddish yellow (Munsell 7.5YR 6/8); *callus tuft* including sharp tip 3.5-4.6mm, reddish yellow to strong brown (Munsell 7.5YR 6/8-5/8), the *callus scar* (0.57-)0.62-0.74 x c. 0.15mm wide; *lemma lobes* absent, or rarely present, 0.20-0.45mm; *lemma crown hairs* absent, rarely up to 3 hairs on one side of lemma margin exceeding awn base by 0.37-0.40mm; *awn* twice kneed, stout, very minutely densely pubescent, the *column* 35.0-54.0(-57.0) x 0.45-0.50mm diameter above articulation and (25.0-)26.0-37.0(-41.0)mm to first knee, the column hairs 0.26 x 0.02mm diameter, moderately dense below, very dense above, the bristle with eight rows of hairs 0.1mm long. *Palea* (6.8-)7.2-8.0(-8.8)mm, the tip and margins hyaline, reaching to c. 0.4mm below top of lemma, and dorsal surface horny and completely hairless. *Anthers* usually 1 larger + 2 smaller, sometimes equal in chasmogamous florets, bright yellow; in chasmogamous florets the larger 5.4-6.6mm, the smaller 5.3-5.6mm, when equal 2.3-4.8mm; in cleistogamous florets the larger 1.2-1.3mm, the smaller 1.0-1.3mm. *Lodicules* three, the two anterior c. 3.0mm swollen, the posterior c. 2mm, thin and delicate.

SOUTH AUSTRALIA. - Southern Lofty: Mount Lofty, Nov 1924, *Ising* (K); Dec 1954, *Hilton 1170* (ADW); Echunga near Kinchina, Sept 1922, *Cleland S16* (K).

VICTORIA. - Central [Melbourne]: Ringwood, Sheet 1, Oct 1891, *Morrison* (K), Oct 1934, comm. *Sonenberg* (K), Dec 1929, Sheets 1 and 2, *Sonenberg* (K); Without definite locality: May 1899, *Williamson 692* (MEL).

TASMANIA. - West: Pieman River bridge, cliffs, Jan 1937, *Davis* and *Davis 10578* (NSW). North: Latrobe River, 1854, *Mueller* (K, BM). Central Plateau floristic zone: Mount Field National Park road, banks of Tyenna River, Dec 1967, *Townrow* (HO). South East: New Norfolk, 2 sheets, Nov 1840, *Gunn 996* (K, HO); Goat Hill, Dec 1946, *Curtis 120* (K); Middle slopes of Mt. Wellington, Jan 1949, *Burbidge 25116* (CANB, HO), Jan 1949, ? *3189* (K); Near Longley, Jan 1962, *Phillips* and *Vickery* (CBG); Hobart, Domain, Beside recreation ground above Brooker Highway, Oct 1966, *Townrow 1* (HO), On NNE side of T.C.A. Ground, Nov 1967, *39* (HO), Oct 1968, *205* (HO), Nov 1928, 2 sheets, *Rodway* (HO); Jan 1930, *Rodway* (HO); University of Tasmania, Bank by Agric. Science Glasshouse, Nov 1967, *Townrow 79* (HO), Sir John Fisher College, cliff above road, Dec 1967, *80* (HO); Mount Nelson, Jan 1947, *Curtis 124* (K); Taroona, Quarantine Station, cliff top outside fence, Nov 1966, *Townrow 5a* (HO); Kingston Beach, Nov 1935, *Rodway 10577* NSW); Channel Highway opposite Alonnah, Jan 1967, *Townrow 27* (HO); North Bruny Island, Roadside near Quarantine Station entrance, Jan 1968, *Townrow 146* (HO), Dennes Point/Barnes Bay road, second steep corner travelling N (opposite the "Iron Pot"), Jan 1968, *138* (HO), Roadside, Ferry/Barnes Bay signpost, Dennes Point road, Jan 1968, *135* (HO), Great Bay, Jan 1970, *247* (K). North East: Roadside E of Launceston, Jan 1949, *Burbidge 2945* (K); Waterhouse Estate (W of Tomahawk), by shelter but on reclaimed dunes, Dec 1967, *Townrow 111* (HO); Roadside 6km NW of St. Helens on Goshen road, Jan 1968, *Townrow 193* (HO); Ansons Bay road, 10km N of Priory, Jan 1968, *Townrow 191* (HO). East: Roadside, Midland Highway, 2km SE of Powranna, Dec 1967, *Townrow 130* (HO); South Arm, Goat Bluff, roadside opposite small lagoon, Nov 1967, *Townrow 58* (HO); East Coast Highway, Sloping roadside opposite quarry 3km N of Sorell, Nov 1967, *Townrow 60* (HO), Roadside in open eucalypt woodland 6km W of Runnymede Post Office, Nov 1967, *62* (HO), Roadside 8km E of Buckland Post Office, Nov 1967, *67* (HO), Roadside beside tall sclerophyll at Coles Bay turnoff, Jan 1968, *178* (HO), Roadside by Millars Causeway, 8km N of Triabunna, Jan 1968, *176* (HO), Roadside 100m S of Raspin's Creek, 5km N of Triabunna, Jan 1968, *173* (HO); Between Cape Bernier and Cockle Bay, Jan 1945, *Curtis 18B* (K); Tasman Highway, Copping, Jan 1949, *Vickery* (NSW), Jan 1949, *Blake 18278* (K), Roadside by Carlton River Bridge, SE of Copping, Dec 1967, *Townrow 107* (HO), Rough ground on W side of Dunalley Bridge, Dec 1967, *Townrow 102* (HO), Roadside near Dunalley,

Nov 1959, *Curtis* (HO), Eaglehawk Neck, Jan 1949, *Vickery 8565* (NSW), Eaglehawk Neck, Feb 1947, *Curtis 129* (K). Without definite locality: *Gunn 588* (K); *Archer* (HO).

Distribution: Vicinities of Adelaide in South Australia and Melbourne in Victoria, widespread in eastern Tasmania.

Ecology: In Tasmania, woodland scrub and heath and roadsides in flatter areas at altitudes mostly below 270m, rarely above 700m.

Notes: 1. *S. pubinodis* has been much confused with *S. pubescens* R. Br. of New South Wales and Southern Queensland (Appendix 3B). Hooker (1856) included *S. pubinodis* with *S. pubescens* R. Brown (1810) and cited the Tasmanian specimens *Gunn 588, 966* and *1453*. Hughes (1921) regarded *S. pubinodis* as a dubious species closely allied to *S. pubescens* stating that the Tasmanian specimens *Gunn 588* and *996*, Mount Direction *Gunn*, Latrobe *Mueller*, Port Dalrymple *Paterson* and Van Diemans Land *Llotsky* all agree with the type of *S. pubescens (Brown 6203)*. Hubbard, in a note dated July 1939, on the sheet *S. pubinodis Gunn 588* (fig. 6, specimen '1) affirmed that the specimen "represents the same species as the type of *S. pubinodis* Trin. and Rupr. (V.D.L. 11) in Leningrad Herbarium", which however he identified as *S. pubescens*. Morris in a further note on the sheet *Gunn 588* commented that "I have studied this mountain form. The outer glumes are softer and more hyaline when growing on the lee sides of forest clearings".

Reexamination of *Gunn 588* and the type of *S. pubescens (Brown 6203)* showed differences in several characters (Appendix 3B) the most striking dissimilarities being between the paleas, the ligules and the A.L.S.O. In *S. pubinodis* the palea is horny-backed with an acute tip and equal to the lemma in length, the lower ligules especially are hard, rotund-obtuse and up to 4mm long, and the A.L.S.O. is of moderately dense antrorse *macrohairs*, whereas in *S. pubescens* the palea is a delicate hyaline blunt-tipped membrane only about three-quarters the length of the lemma, the ligules are erose membranes c. 0.5mm long, and the A.L.S.O. is of dense antrorse *prickle hair hooks*.

Hubbard, after further examination in August 1970 of the ligule and spikelet characters of the Leningrad type-specimen of *S. pubinodis*, and of the A.L.S.O. of a gathering made by Gunn in Tasmania representing the same species as the type, confirmed my observations. In his report *(pers. comm.)* Hubbard noted that it was not possible to determine who wrote the label "V.D.L.11" which appears on the type sheet but that a small slip with drawings in ink of the spikelet and its parts attached to the type-sheet is labelled in Trinius's hand "Stipa pubinodis m". He noted that there seems little doubt that the Tasmanian specimens, including the specimen subsequently designated by Trinius to *S. pubinodis*, sent to Trinius by Sir W.J. Hooker, were duplicates from Ronald Gunn's extensive collections. He also stated that the type [of *S. pubinodis*] is very similar to specimens gathered by *Gunn*, no. 966, at New Norfolk, Tasmania in November 1840 and on Mt. Direction, Tasmania in December 1841, and represents the same species. He agreed that this material, included in *Stipa pubescens* by Hughes and by Hooker, may be distinct as I suggest.

Gunn 588 and *Gunn 996* are correctly identified as *S. pubinodis* and the Tasmanian populations belong to this species and not to *S. pubescens* (as formerly stated by Townrow 1970, p.84).

Of the other specimens cited by Hooker and/or Hughes Latrobe River, 1854, *Mueller* (K.BM) belongs to *S. pubinodis;* New Norfolk, 15.11.1840, *Gunn 996* (K) and New Holland, *Llotsky* (K) vary from the type of *S. pubinodis* in having sparse closely adpressed hairs c. 0.5mm long on the awn columns; *Gunn 1453* (K) and Van Diemans Land, *Llotsky* (K) are both immature specimens of *Stipa stuposa* Hughes having the A.L.S.O. and lemma crown hairs characteristic of that species; I have not seen Mount Direction, *Gunn* or Port Dalrymple, *Paterson*.

2. Complete discontinuity between *S. pubinodis* and *S. pubescens* cannot confidently be claimed as a number of specimens (New South Wales, Blackheath, Jan 1950, *Constable* (K); Brisbane River, May 1827, *Cunningham* (K)) have intermediate lemma and A.L.S.O. characters.

7. *STIPA BIGENICULATA* Hughes, *Kew Bull., 1922*, p. 20 (1922); Burbidge and Gray, *Fl. A.C.T.*, p. 52 (1970); Burbidge, *Austral. Grasses*, 1, p. 70 (1966).
(Figure 7; Plate 1, figure 7)
Holotype: New South Wales, Cooma, Jan 1887, *Baker* (US).

Perennial, densely caespitose; *culms* up to 0.5m, erect, terete, 2-4 noded, the nodes exserted; *nodes* densely retrorse-pubescent with a felt of minute white hairs. *Leaf sheaths* 15-30mm, finely striate, pale green, the lower sheaths lightly retrorse-pubescent, the hairs up to 1mm, fine and silky, the upper sheaths glabrous; *ligule* up to 0.5mm, minutely ciliate, with sparse fine tufts of silky hairs up to 3mm on either side in position of auricles; *blades* up to 450 x 2mm wide at base when flattened, setaceo-convolute, somewhat pungent pointed, *abaxial surface* lightly grooved, lower blades moderately densely antrorse-scabrous, the hairs to 0.5mm, upper blades smooth, *adaxial surface* deeply grooved, hairless, *A.L.S.O.* of *abundant, mostly antrorse, some retrorse, oval-based prickle hair hooks 20-35 x 15µ diameter at base*, the hooks in regular rows alternating with several silica bodies and short cells within the rows, epidermal long cells c. 70 x 10µ wide. *Panicle* up to 250 x 30mm wide, the base long exserted from uppermost sheath, slightly contracted, the main rachis slightly scabrous with up to 7 nodes, the lower nodes up to c. 60mm apart with 2-4 slightly scabrid 1-3-nate slender branches up to 60mm each bearing 1-10 spikelets on slender minutely scabrous pedicels up to 1 cm long. *Spikelets* chasmogamous or cleistogamous, yellowish-green soon straw coloured, the glumes somewhat spreading. *Glumes* unequal, chaffy below with delicate often torn tips, *lower glume* 15.0-20.5mm (when torn 15.0-17.0mm), 3-nerved, glabrous, *upper glume* 13.0-14.0+mm (when torn (8.9-)10.0-14.0mm), 5-nerved, very minutely hairy between the nerves in the upper quarter, otherwise glabrous. *Lemma* (7.3-)7.8-10.5 (including callus tuft and tip) x 0.7-1.2mm wide, firm, narrowly obovate, the margins meeting, *velvety, hairy, reddish-yellow* (Munsell 7.5YR 6/6), the body beneath the hairs slightly darker (7.5YR 7/6) and minutely scabrid in the neck region, the hairs c. 0.63 x 0.01mm diameter at base, at an acute angle to the body, forming a dense pinkish-white felt (Munsell 7.5YR 8/2); *callus tuft* including sharp tip 2.7-3.8mm, pinkish-white (Munsell 7.5YR 8/2), the *callus scar* 0.55-0.70 x c. 0.15 mm wide; *lemma lobes* absent or 0.02-0.27 (-0.37)mm, obtuse, minutely ciliate, the cilia 0.05-0.07mm, *lemma crown hairs (2.2-)2.4-4.4mm of c. 20 hairs; awn* twice kneed, very minutely hairy to the tip of the bristle, the hairs c. 0.22 mm, erect and closely adpressed, the *column* 20.0-25.0 x 0.30-0.37mm diameter above articulation and 12.0-18.0 mm to first knee. *Palea* (4.8-)5.0-7.0(-7.4)mm, the tip delicate and level with the top of the lemma, thinner than the lemma, very minutely hairy between the two faint dorsal nerves. *Anthers* usually 1 larger and 2 smaller, rarely equal; in chasmogamous florets the larger 3.4-4.4mm, the smaller 3.3-3.6mm; in cleistogamous florets the larger 1.0-2.8mm, the smaller 0.8-2.5mm. *Lodicules* two large anterior c. 2.4mm and one small posterior c. 1.4mm.

SOUTH AUSTRALIA. - Southern Lofty: Adelaide, Oct 1928, *Cleland* (AD96323194); Beaumont, Oct 1926, *Cleland* (K); Belair, Oct 1935, *Eardley*.

NEW SOUTH WALES. - Southern Tablelands: Cooma (K462); Canberra *Cambage 3069* (K); Jan 1948, *Thomas* (K); Black Mountain, lower E slopes, Dec 1962, *Pullen 3735* (K); Black Mountain, lower E slopes, C.S.I.R.O. grounds, Nov 1968, *Pullen 3955* (K).

VICTORIA. - Central [Melbourne]: St. Albans, Feb 1932, *Sonenberg* (K); St. Albans, Nov 1929 (2 sheets), *Patton* (K).

TASMANIA. - South East: Queens Domain, Dec 1943, *Curtis 126* (K); North Bruny Island, Bull Bay, S end, Jan 1968, *Townrow 162* (HO). East: Hobart, Eastern Shore near Bowen Park, roadside 1km N of Old Beach turnoff, Dec 1967, *Townrow 96* (HO); Evandale, by South Esk Bridge, Dec 1967, *Townrow 115* (HO).

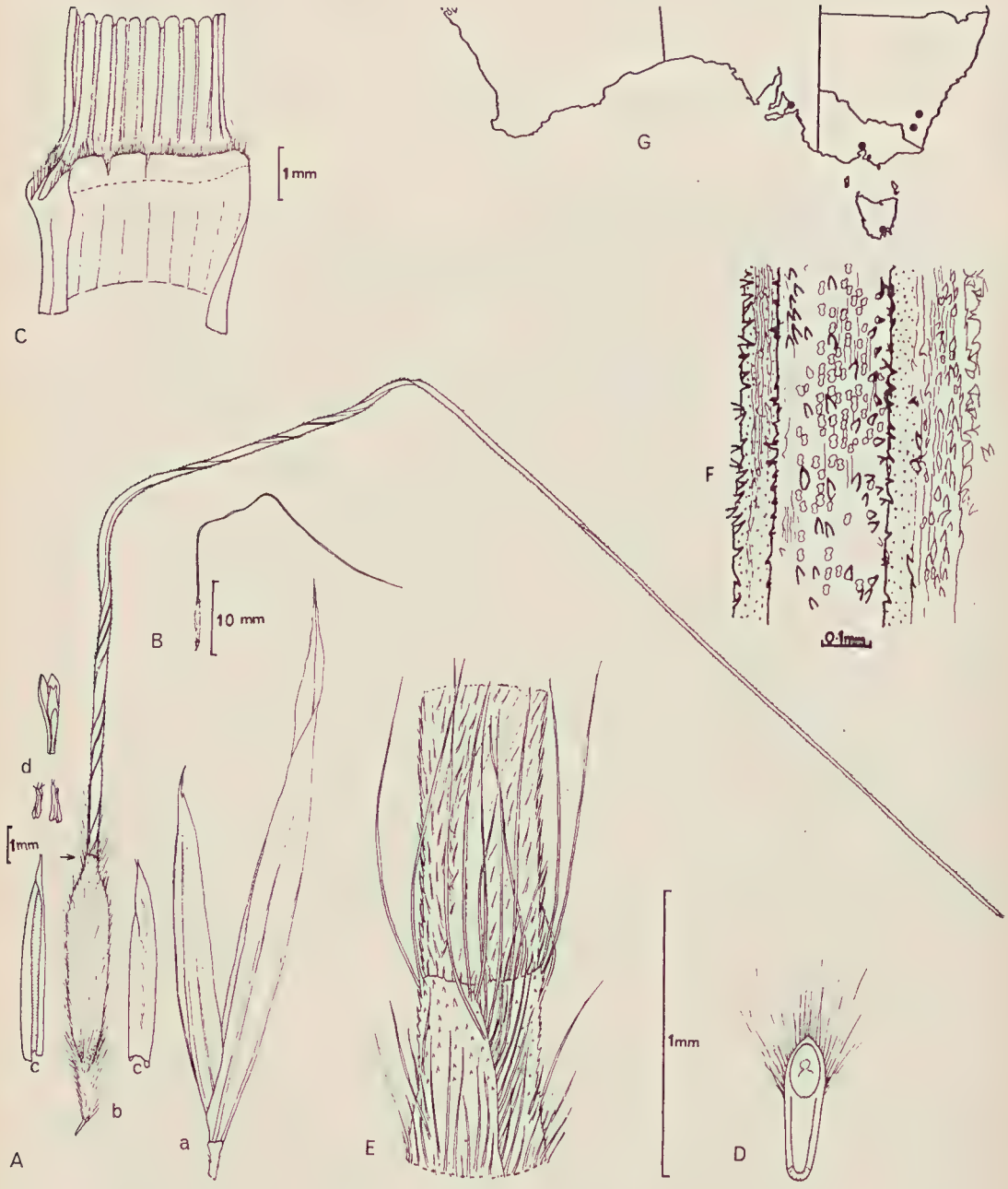

FIG. 7. - *Stipa bigeniculata* Hughes, Jan. 1948 "Thomas" (K) (matched with type specimen). Explanation as for figure 1 (p.236) except: C. Ligule (2nd of 3 culm blades). F. Tracing of micrograph of part of area shown in Plate 1, fig. 7.

Distribution: South eastern Australia in vicinities of Adelaide Canberra and Melbourne; southern New South Wales; Tasmania.

Notes: 1. *S. bigeniculata* in Tasmania may have been confused with the abundant and probably related *S. stuposa* (fig. 9) which also has a hair tuft round the awn base. It differs from *S. stuposa* in its shorter, reddish-yellow lemma body, the more minute hairiness of its awn, and in its A.L.S.O. (compare fig. 7 with fig. 9).

2. *S. bigeniculata* may be distinguished from *S. flavescens* by the A.L.S.O., the almost hairless palea, and the stouter, less twisted awn column, and in mature specimens the lemma colour (compare fig. 7 with fig. 2).

3. Suspected *S. stuposa/S. flavescens* hybrids are very similar to *S. bigeniculata* but have a coarser A.L.S.O. of prickle hair hooks 0.05mm long instead of 0.025mm long.

4. On the basis of both lemma characters and A.L.S.O., *S. bigeniculata* has most morphological resemblances to *S. aristiglumis* Muell., which has not been recorded in Tasmania.

8. *STIPA CLELANDII* Summerhayes and Hubbard, *Kew Bull., 1927*, p. 362.
(Figure 8; Plate 1, figure 8)
Holotype: South Australia, Kinchina, Nov 1924, *Cleland S40* (K).

Caespitose perennial; *culms* c. 1m, moderately slender, unbranched, firm, terete, glabrous, smooth, 4-noded; *nodes* and just below nodes retrorse short-white-silky hairy. *Leaf* sheaths close, shorter than internodes, lower sheaths rough with short stiff hairs, upper sheaths hairless, smooth, sheaths ciliate, collar region with white hairs; *ligule* 0.5-1.0mm, truncate, ciliate, the cilia c. 0.2mm; *blades* 110-360 x 3-3.5mm wide at the base when flattened, involute narrow-linear, with long fine tip, firm, rigid; slightly rough to touch, *abaxial surface* setoso-pillose becoming smooth, *adaxial surface* shortly densely pubescent, *A.L.S.O.* of moderately dense macrohairs and very few prickle hair hooks, the macrohairs (35-)70-210 x c.15μ diameter at base, with collar and ± swollen bases, slightly tangled, springing ± at right angles to the ribs then sharply bending, mostly retrorse over the spaces between the ribs, the antrorse hooks 20-30 x c. 10μ diameter at base, epidermal long cells obscured by wax platelets. *Panicle* 200-250 x 15-35mm wide, sub-dense, the rachis terete, slightly striate, scabrous, lower nodes silky-hairy, branches ± erect, up to 6cm, c. 4-nate, slender rough to touch. *Spikelets* chasmogamous, moderately turgid, pale straw coloured or purplish. *Glumes* unequal with delicate often torn tips, *lower glume* 16.0-20.0mm, thinly papery, narrow lanceolate, clearly 3-nerved, minutely scabrous on the mid-nerve otherwise smooth, glabrous, *upper glume* 12.0-16.0mm, narrow lanceolate-oblong, 5-nerved, minutely densely scabrid between the nerves, the nerves scabrous on the backs. *Lemma* 7.0-8.0 (including callus tuft and tip) x c. 1.2mm wide, cylindrical, moderately turgid, the margins overlapping, pubescent, yellowish brown (Munsell 10YR 5/4), the body beneath the hairs reddish-brown (Munsell 5YR 2/2) and minutely pimpled (the pimples c. 0.05mm diameter) over the upper 1/7, the hairs c. 1.1 x 0.02mm diameter at base, very dense, twisting clockwise round the back of the lemma at c. 45°, pale yellow (Munsell 2.5Y 7/4); *callus tuft* including sharp tip 2.5-3.6mm, very pale brown (Munsell 10YR 7/4), the callus scar 0.62-0.70 x c. 0.12mm wide; *lemma lobes* absent, a few cilia c. 0.5mm on free edge of lemma in lobe position; *lemma crown hairs* 2.5-5.0 mm, dense, the hairs uneven, long at sides, short at back; *awn* bigeniculate, adpressed sparsely-densely pubescent, the *column* 18.0-21.0 x 0.35-0.37mm diameter above articulation and 9.0-10.0mm to first knee, the column hairs of two lengths c. 0.25mm and c. 0.12mm, the shorter hairs also along the bristle-angles. *Palea* 5.0-6.2mm, equalling lemma in length, slightly thinner in texture than lemma, tip firm membranous, densely pillose on the back like the lemma. *Anthers* c. 1.0mm. *Lodicules* three ± equally developed, two of them c. 2.25mm, the other c. 1.75mm.

FIG. 8. - *Stipa clelandii* Summerhayes and Hubbard, "Sheet 2, Cleland S.40" (K) (type specimen). Explanation as for figure 1 (p.236) except: C. Ligule (blade 2 from culm base). F. Tracing of micrograph of part of area shown in Plate 1, fig. 8.

SOUTH AUSTRALIA. - Southern Lofty: Kinchina, Nov 1924, (2 sheets), *Cleland S40* (K).
TASMANIA. - East: Richmond, Oct 1966, Comm. *Morris* (HO).

Notes: On the basis of spikelet characters and A.L.S.O., this apparently rare species has phenetic relationships with the mainland species *S. blackii* Hub. and the Tasmanian species *S. stuposa* Hughes, occupying a median position between them (see Appendix 2C; Appendix 3C; fig. 8; fig. 9).

9. *STIPA STUPOSA* Hughes, *Kew Bull., 1921*, p.20 (1921); Townrow, *Pap. Proc. R. Soc. Tasm.*, 104, p.86 (1970).

(Figure 9; Plate 2, figure 9)

Holotype: Tasmania, New Norfolk, Jan 1840, *Gunn 1480* (K).

Short-lived perennial, caepitose, *culms* 0.8-1.4m, up to 3.5mm diameter at base, erect or geniculate, 3-5 noded; *nodes* exserted, nodes and upper parts of internodes minutely densely retrorse-pubescent, the hairs c. 0.3mm, white. *Leaf sheaths* lightly striate, the lower sheaths moderately pubescent with spreading hairs c. 0.5mm, outer sheath margins ± ciliate at least below, orifice and collar bearded with fine white hairs up to 1mm, finally breaking down into long twisted fibres; *ligules* c. 0.2mm, truncate, ciliate, the hairs c. 0.3mm, minutely hairy on the back; *blades* 190-300 x up to 5.0mm wide at the base when flattened, linear, convolute, tapering with long drawn out tips, stiff and harsh, silvery green, *abaxial surface* lightly striate, ± minutely hoary with stout swollen-based macrohairs c. 0.8 x 0.05mm diameter at base and retrorse prickle hairs c. 0.08 x 0.01mm diameter at base between the veins, *adaxial surface* deeply grooved, *sparsely shaggy-pubescent, A.L.S.O. of macrohairs and prickle hairs,* the macrohairs 100-450 x 15-20μ diameter at base, and moderately dense on the lower blades, becoming shorter and sparser on higher blades, kneed, both antrorse and retrorse, tapering finely from somewhat swollen bases, the prickle hairs 20-30 x 10-15μ diameter at base, abundant, more frequent towards the rib margins, *mostly of retrorse hooks,* some straight prickles vertical to rib surfaces, epidermal long cells 35-55 x 10-15μ wide, straight sided, relatively short. *Panicle* 170-350 x c. 70mm wide, narrowly contracted, exserted, the main axis terete, minutely hairy, with c. 6 nodes each with c. 6 slender 1-3-nate minutely hairy branches up to 100mm, the spikelets towards the ends of the branches on minutely scabro-pubescent pedicels 2-8mm. *Spikelets* chasmogamous or cleistogamous, pale-coloured, somewhat gaping. *Glumes* unequal, chaffy with delicate often torn tips, very minutely rough on and between the nerves, *lower glume* 18.0-24.0+ mm (torn 15.0-24.5mm), clearly 3-nerved, *upper glume* 15.0-20.0mm (torn 11.5-19.0mm), clearly 5-nerved. *Lemmas (7.6-)7.9-11.5* (including callus tuft and tip) x *0.7-1.2mm wide,* firm, narrowly obovate, the margins overlapping, pubescent, dark reddish brown (Munsell 5YR 3/4), the body beneath the hairs dark reddish brown and minutely rough with prickle hairs c. 0.02mm on upper 1/10 of length, the hairs c. 1.0 x 0.01mm diameter at base, moderately dense at 30-40° to body, very pale brown (Munsell 10YR 8/4); *callus tuft* including sharp tip (3.0-)3.2-4.3mm, brownish yellow (Munsell 10YR 6/6), the *callus scar* 0.52-0.75 x c. 0.13mm wide; *lemma lobes* 0.10-0.25 (-0.27)mm, ovate, ciliate; *lemma crown hairs tuft of c. 20 uneven hairs, the longest extending (1.2-)1.5-3.0mm beyond base of awn; awn* twice kneed, the *column* 19.0-36.5 x 0.32-0.42mm diameter above articulation and 11.0-25.0mm to first knee, hairy, the hairs uneven, 0.7-1.0mm, moderately dense at 35° to awn surface, becoming shorter towards the bristle, the bristle very minutely hairy to the tip, the hairs c. 0.1mm. *Palea* 6.0-7.8mm, horny with very narrow hyaline margins, the membranous tip reaching to 0.4mm below top of lemma, the dorsal surface between the two nerves as hard and hairy as the lemma. *Anthers* in chasmogamous florets usually equal in length, 4.0-6.0mm, in cleistogamous florets usually one larger + two smaller, the larger 0.9-2.0mm, the smaller 0.4-1.6mm. *Lodicules* three, the two anterior c. 3.0mm, the posterior c. 1.0mm.

TASMANIA. - Central: Poatina, two bends down from Penstock, Dec 1967, *Townrow 131* (HO). South East: New Norfolk, Jan 1840, *Gunn 1480* (K); Austins Ferry, N Boundary, roadside, Dec 1968, *Townrow 228* (HO); Queens Domain, Dec 1943, *Curtis 125* (K); Domain, roadside near Tennis Courts, Nov 1967, *Townrow 35* (HO); Sandy Bay, Jan 1902, *Maiden* and *Cambage K460* (NSW); Hobart, Jan 1930, *Rodway* (HO); Mt. Nelson, Jan 1947, *Curtis 127*

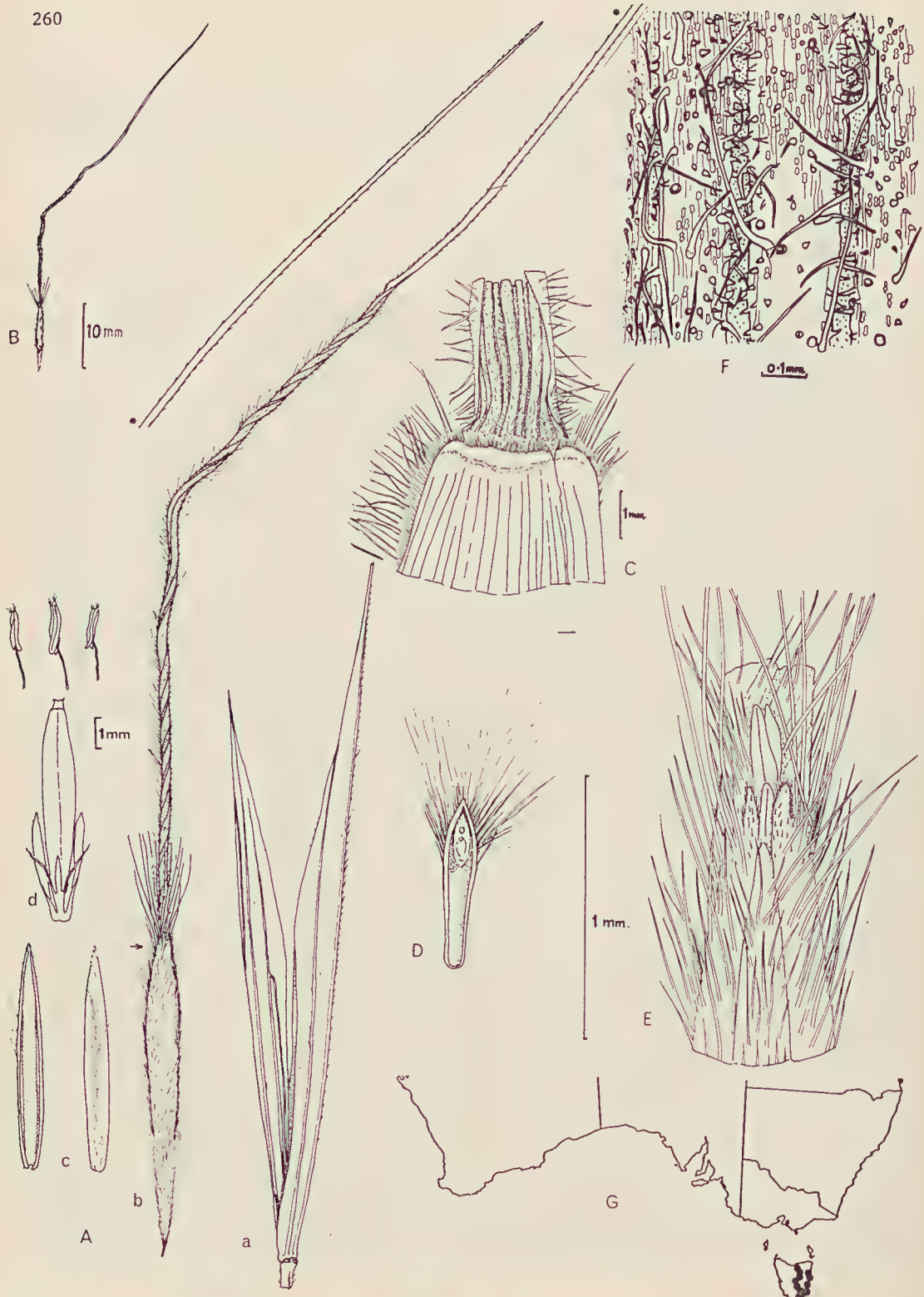

FIG. 9. - *Stipa stuposa* Hughes, "Gunn 1480" (K) (type specimen). Explanation as for figure 1 (p.236) except: C. Ligule (blade 2 from culm base). F. Tracing of micrograph of part of area shown in Plate 2, fig. 9.

(K); University of Tasmania, by Agric. Science Glasshouse, Jan 1970, *Townrow* (K); Bonnet Hill, roadside N of stone quarry, Jan 1968, *Townrow 164* (HO); Kingston Beach, Nov 1935, *Rodway 2058* (K); North Bruny Island, Great Bay, low sandy strip between road and beach, Jan 1970, *Townrow 249* (K). North East: 9.5km E of Launceston, Jan 1949, *Burbidge 2934* (CANB). East: "Levendale" near O'Connors Peak, c. 24km W of Conara Junction, outside shearing shed, Dec 1967, *Townrow 116* (HO); Derwent River, Eastern Shore opposite Cadbury's Factory, Dec 1967, *Townrow 98* (HO), Half mile along Old Beach/Bowen Park road, Dec 1967, *95* (HO); Risdon, Hill above Derwent, Jan 1949, *Burbidge 3186* (CANB), Jan 1949, *3185* (CANB, K), Jan 1949, *Blake 18324* (NSW, K); South Arm, Bank opposite "Karanga", Opossum Bay, Nov 1967, *Townrow 44* (HO), Roadside 5km S of Opossum Bay, Nov 1967, *50* (HO); Eastern Shore, Warrane, roadside E boundary, Nov 1966, *Townrow 7* (HO); Slopen Island, cliff top SW side, Dec 1967, *Townrow 86* (HO); Bust-Me-Gall Hill, Nov 1967, *Townrow* (K); Carlton River Bridge roadside, 5km SE of Copping, Dec 1967, *Townrow 105* (HO); Port Arthur, 1848, *Home* (BM); Beside Prosser River, 5km W of Orford, Nov 1967, *Townrow 69* (HO); "Double Creek", 3km N of Orford, Jan 1968, *Townrow 172*. Without definite locality: *Gunn 1453* (K); Van Diemans Land, *Llotsky* (K).

Distribution: Endemic in eastern Tasmania.

Ecology: Frequent in open and cleared areas of low and grassy woodland, open woodland, scrub and heath, mostly between altitudes of 30-180m with annual rainfall below 1140mm.

Notes: *S. stuposa*, the most common speargrass in Tasmania, has morphological resemblances to *S. bigeniculata*, *S. clelandii* (fig. 8) and to *S. blackii* (Appendix 3C) all of which possess a lemma hair crown about 3mm long. The four species are closely similar in several other features e.g. the ligule, and may form a series in which other diagnostic characters vary in a regular way e.g. decreasing length of lemma body plus callus tuft, and length, hairiness and texture of the palea (compare figs. 7, 8, 9 and Appendix 3C).

A comparison of the type specimens (Appendix 2C) suggests that morphologically *S. stuposa* is more closely allied to *S. clelandii* than to *S. blackii*. *S. stuposa* is distinguished from *S. clelandii* by its longer glumes, its longer brownish lemma with more hairy column and lemma lobes, the longer, more densely hairy, horny palea and the A.L.S.O.

A comparison of A.L.S.O. in conjunction with spikelet characters suggests that *S. bigeniculata* provides a possible morphological link between the series *S. stuposa*, *S. clelandii*, *S. blackii* and the series *S. aristiglumis*, *S. puberula*, *S. flavescens* (compare Plate 1, figs. 2, 7, 8, 9; Plate 2, fig. C, and figs. 2, 7, 8, 9; Appendix 3C).

10. *STIPA STIPOIDES* (Hooker f.) Veldkamp, *Blumea*, 22, p.11 (1974). Syn. *Dichelachne stipoides* Hooker, *Fl. Tasm.*, 1, p.294 (1853); Hooker, *Fl. Tasm.*, 2, p.112 (1858).
(Figure 10; Plate 2, figure 10)
Lectotype: New Zealand, Bay of Islands, *Hooker* (K). [Here designated]
Stipa teretifolia Steudel, *Synops.Plant.Glum.*, 1, p.128 (1854); Bentham, *Fl. Austral.*, 7, p.567 (1878); Hughes, *Kew Bull.*, *1921* p. 12 (1921); Willis, *Handbook to Plants in Victoria*, p.182 (1962); Townrow, *Pap. Proc. R. Soc. Tasm.*, 104, p.86 (1970). (Type: Australia, Western Port, *D'Urville*.)

Long-lived perennial; caespitose often forming large tussocks; *culms* 0.3-0.9m, erect, terete, wiry, yellow, smooth and polished, 3-4-noded, the upper node exserted; *nodes* and internodes grading imperceptibly, smooth and shining. *Leaf sheaths* lightly striate, glabrous, pale green, soon turning yellow or light brown; *ligule up to 7mm, white, membranous, pointed*, hairless; *blades* 200-700 x 1mm wide, *stiff, erect, needle-like, pungent pointed, extending beyond the inflorescences and culms, tightly inrolled,*

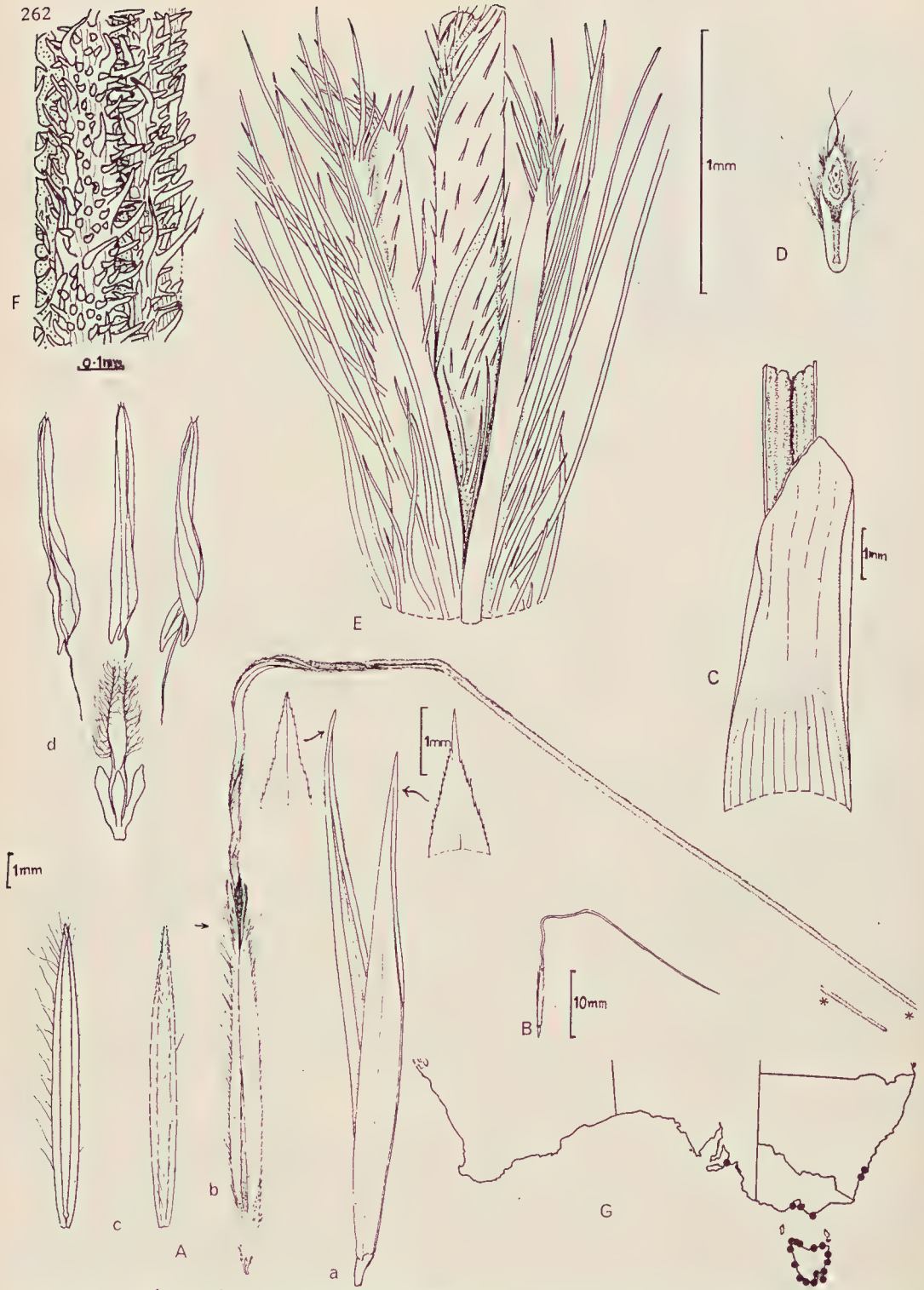

FIG. 10. - *Stipa stipoides* (Hooker) Veldkamp, "Tilden 754" (K). Explanation as for figure 1 (p.236) except: Spikelet characters:- A. a. glumes (tips x10). C. Ligule (blade 2 from culm base). F. Tracing of micrograph of part of area shown in Plate 2, fig. 10.

the margins apposed, *abaxial surface smooth*, shining, *adaxial surface* deeply grooved, *densely covered with finger-like hairs*, *A.L.S.O.* of macrohairs and prickle hairs, the macrohairs 35-150 x 14-35µ diameter at base, blunt tipped, mostly somewhat ascending, the longer hairs sinuous with slightly swollen bases, the prickle hairs 14-21 x c.14µ diameter at base, like smaller versions of the macrohairs, the epidermal long cells c.57 x 8µ wide, straight-sided. *Panicle* 110-220 x c.20mm wide, contracted, finally exserted, *strict, erect, few flowered and sparingly branched*, c. 6-noded, the lower nodes 20-50mm apart with 1-3 smooth, glabrous, slender 1-3-nate branches up to 40mm each bearing 1-5 spikelets towards the end on filiform glabrous pedicels 2-9mm long. *Spikelets* chasmogamous, soon straw-coloured, narrow. *Glumes* about equal, the upper occasionally longer than the lower, chaffy, white or yellow, glabrous, thin and shining, lanceolate with a long slender delicate point, *lower glume* 15.0-21.0mm (when torn 14.0-19.5mm), delicately 3-nerved, the lateral nerves weakly developed, *upper glume* 15.0-21.0 mm (when torn 16.0-20.5mm), delicately 5-nerved. *Lemma* (8.5-)10.0-12.5 (including callus but excluding lemma lobes) x 0.8-1.2mm wide, firm, narrowly obovate, the margins meeting above, gaping below, pubescent, reddish brown (Munsell 5YR 4/4), the body yellowish red (Munsell 5YR 5/6) and smooth, the hairs 1.0-2.0 x 0.01-0.02mm diameter at base, moderately dense, shorter and finer below, becoming longer and stouter above, at c. 15° to body, white (Munsell 5YR 8/1); *callus tuft* including sharp tip 2.0-2.6mm, yellow (Munsell 2.5Y 8/8), the *callus scar* (0.37-)0.45-0.50 x c. 0.12mm wide; *lemma lobes (1.4-)1.8-3.2(-3.6)mm, visible to the naked eye*, acute, long ciliate, the hairs up to 1.5mm; *lemma crown hairs* absent, body hairs exceed awn base by c. 1.8mm; *awn* twice kneed, stout, minutely pubescent, the *column* 10.0-14.0 x 0.20-0.25mm diameter above articulation and *4.5-7.0mm to first knee*, the column hairs 0.1-0.2mm, moderately dense in bands on either side of the nerve grooves, extending to the end of the bristle. *Palea* 8.0-12.0mm, similar to lemma in texture and hairiness, the tip extending 0.5mm beyond the top of the lemma plus the palea hairs extending a further 0.9mm. *Anthers* three, maroon coloured, equal or 2 large and 1 small or 1 large and 2 small, the larger 7.5-8.2mm, the smaller 7.3-7.6mm, or when equal 6.0-7.9mm. *Lodicules* three equal, c. 2.0mm.

SOUTH AUSTRALIA. - Southern Lofty: Encounter Bay, Waitpinga, Jan 1932, *Cleland* (K).

NEW SOUTH WALES. - South Coast: N Jarvis Bay, Point Perpendicular exposed cliff face 0.5km N of lighthouse overlooking ocean, Oct 1960, *Constable* (K, NSW 52366); Burrewarra Pt., S of Batemans Bay, sand above high water mark, Oct 1965, *Craven 614* (K).

VICTORIA. - Central [Melbourne]: Point Lonsdale, Oct-Nov 1912, *Tilden 754* (K); Point Lonsdale, Nov 1929, *Robb* (K); Ricketts Point, Oct 1931, com. *Sonenberg* (K); Wilsons Promontory 1877, *Mueller* (K).

TASMANIA. - North: Beach on road from Rocky Cape to Black River, on margin of rocks, Feb 1948, *Curtis* (K). South East: Claremont, Dec 1923, *Lucas* (K); Cornelian Bay, Feb 1894, *Rodway 27* (K); Taroona, rocky crevices above tidemark, beside Quarantine Station, Nov 1966, *Townrow 6* (HO); Kingston Beach, Nov 1935, 2 sheets, *Rodway 2057* (K); N Bruny Island, Great Bay, old jetty at Smootheys Point, Jan 1970, *Townrow 250* (K); Southport, Jan 1962, *Phillips* and *Vickery 001274* (CBG). North East: George Town, *Gunn 1490* (K). East: Hill above Derwent Estuary, shallow soil, Jan 1949, *Burbidge 3183* (K, HO); Risdon, shore rocks, Jan 1949, *Blake 18322* (K), Harbour foreshore, Jan 1949, *Vickery 7491* (K, HO); South Arm, Ralphs bay, one third way round from W end, Nov 1967, *Townrow 54, 54a* (HO); Boomer, Dunalley, Nov 1943, *Curtis 17* (K); Eaglehawk Neck, Jan 1949, *Blake 18280* (K). Without definite locality: 1850, *Archer* (HO).

Distribution: Coasts of south eastern Australia, Tasmania, and North Island of New Zealand.

Ecology: In Tasmania, strictly confined to the strandline and rocks of the coast within the reach of salt spray, and salt water inlets usually associated with rocky shores. On Curtis Island, Bass Strait a constituent of tussock grassland (Kirkpatrick *et al.*, 1974).

Notes: 1. *S. stipoides* is a highly distinct and uniform species with considerable morphological resemblances to *S. juncifolia* Hughes from the Swan River in Western Australia. Both species, with highly distinctive and remarkably similar lemma and A.L.S.O. characters, are markedly xeromorphic and are associated with coastal saline habitats. Both have stiff needle-like, strongly thickened blades with a most distinct A.L.S.O. of finger-like outgrowths (fig. 10F) and well developed, membranous, ligules up to 7mm long which are glabrous in *S. stipoides* but minutely ciliate in *S. juncifolia*. Both have similarly shaped white-silky-hairy lemmas with lobes visible to the naked eye, relatively short blunt callus scars and strongly twice-geniculate, short-columned awns. The lemma body of *S. stipoides* is about twice the length of that of *S. juncifolia*. The floret structure of *S. stipoides* is further notable because of the three large equally developed lodicules and the palea which in the majority of specimens examined, is *longer* than the lemma.

2. The lectotype designated above has not previously been published as such, and has been selected on the following grounds. Dr V.D. Zotov, D.S.I.R., New Zealand, supplied the information *(pers. comm.)* that Hooker's citation: "*Avena angustifolia*, Banks et Sol. Mss (Tab. LXVI). Hab. Northern Island on rocks near the sea. East coast *Banks* and *Solander*, Bay of Islands and Auckland, *Sinclair*, etc.," included three specimens which are:

(i) *Banks* and *Solander* - *Avena angustifolia* (by MS - from Mercury Bay and Bay of Islands) (BM).
(ii) *Hooker* - Bay of Islands, New Zealand (K).
(iii) *Dr Sinclair* - Auckland, clay banks near the sea. *403. New Zealand* (K).

The Banks and Solander material (labelled *S. teretifolia* Steud.) held at BMNH is in poor condition having been repaired after war damage (Second World War). Dr. Zotov suggests that Hooker's specimen (ii above), which has dissections on it, be made the lectotype of the species. With this I concur.

3. Veldkamp (1974) places *Dichelachne setacea* Nees (*Pl. Priess.*, 2, p.98 (1846), non *Stipa setacea* R. Brown (*Prodr.*, p.174; 1810) in synonomy with *Stipa stipoides* giving as its type *Priess 1854* (BM). But, as was drawn to my attention by P.S. Green, Keeper of the Herbarium, Kew *(pers.comm.)* Nees based his binomial *Dichelachne setacea* on *Stipa setacea* R. Brown, citing it as the only synonym and repeating Brown's diagnosis word for word as his description. *Dichelachne setacea* cannot be a synonym of *Stipa stipoides* as Robert Brown's type specimen of *S. setacea* (Port Jackson, *Brown 6202* (K)) which I have studied, is a distinctly different taxon.

11. *STIPA VARIABILIS* Hughes, *Kew Bull., 1921*, p.15 (1921); Willis, *Handbook to Plants in Victoria*, p.185 (1962); Townrow, *Pap. Proc. R. Soc. Tasm.*, 104, p. 86 (1970).
(Figure 11; Plate 2, figure 11)
Holotype: Western Australia, Swan River, *Drummond 961* (K).

Perennial, caespitose; *culms*, 0.3-0.8m, 1.0-1.5mm diameter at base, terete, 1-3 (-4)-noded, minutely densely retrorse-pubescent for c. 1mm below nodes; *nodes* light brown, mostly exserted and smooth or minutely pubescent. *Leaf sheaths* striate, minutely antrorse- or retrorse-hairy or smooth, the outer margins usually ciliate, with white tufts of hairs 1.0-1.5mm in the position of auricles, smooth or minutely hairy in the collar region; *ligules* up to 2mm, minutely ciliate with hairs c. 0.1mm, often lopsided; *blades* 90-250 x 1-3mm wide at base when flattened, involute, linear, attentuate, moderately stiff, silvery green, slightly rough, minutely pubescent, *abaxial surface* lightly grooved, minutely hoary with antrorse and retrorse moderately dense long and short hairs c. 0.50 x 0.05mm diameter and 0.20 x 0.02mm diameter at base, *adaxial surface* deeply grooved with 9 or more ribs, thick and thin ribs alternating, scabrid, very sparsely hairy, *A.L.S.O.* of a few scattered macrohairs and frequent prickle hairs, the macrohairs up to 215 x 15-30μ diameter at base, antrorse, finely tapering, arising at c. 45° to rib surface, usually absent from upper culm blades, the

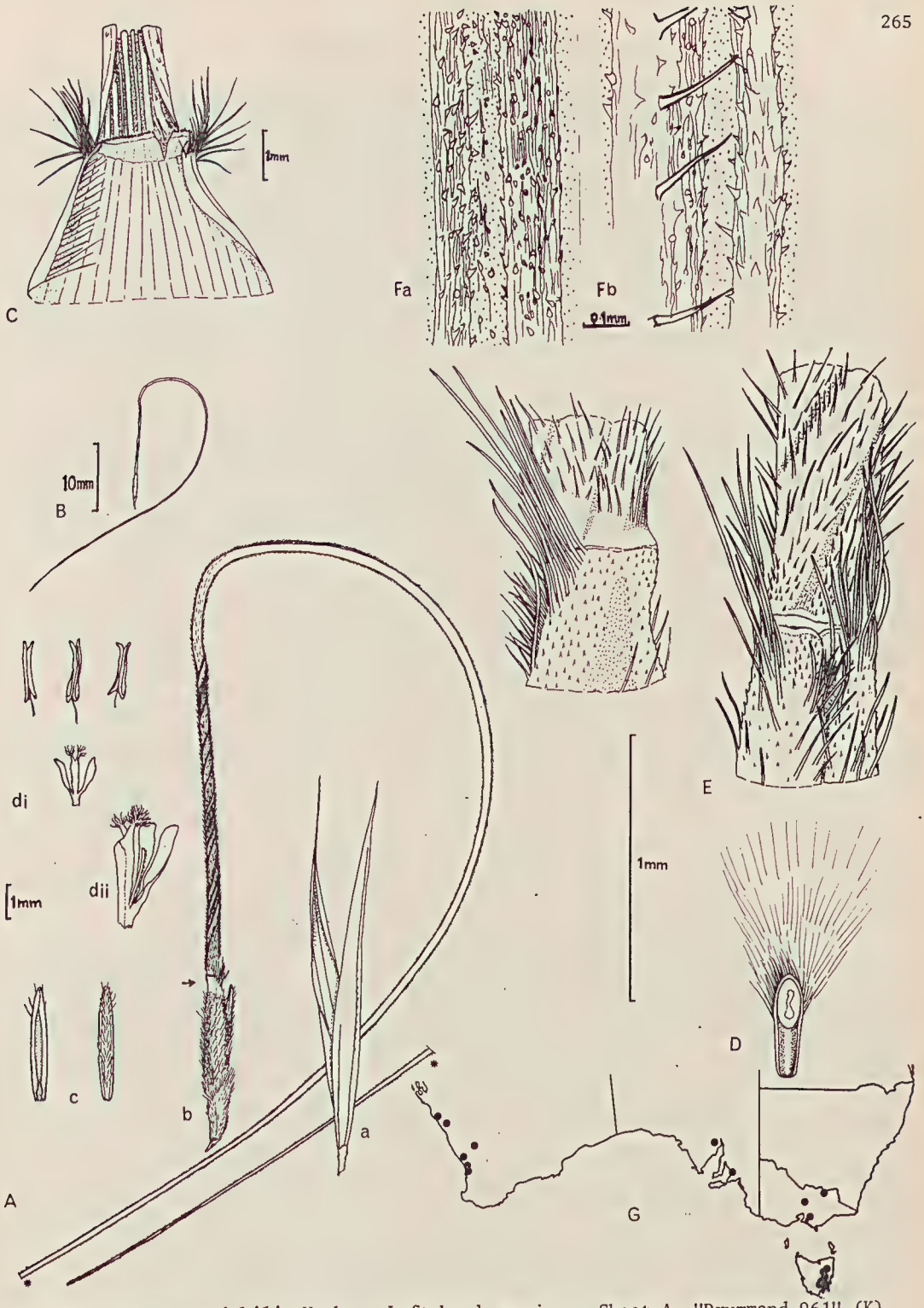

FIG. 11. - *Stipa variabilis* Hughes, Left hand specimen, Sheet A, "Drummond 961" (K) (type specimen). Explanation as for figure 1 (p.236) except: C. Ligule (blade 2 from culm base) "Blake 18049" (matched with type specimen). F. a. tracing of micrograph of part of area shown in Plate 1, fig. 11. b. tracing of micrograph of blade 3 from culm base of "Blake 18049".

prickle hairs 20-40 x 15-20μ diameter at base, mostly with straight points, some antrorsely hooked, in rows alternating with long cells, epidermal long cells 60-90 x 7-14μ wide, spindle-shaped, with 'withy basket' appearance. *Panicle* 150-250 x 20-30mm wide, primary axis terete below, flattened above, smooth or minutely scabrous-hairy, 7-10-noded, the nodes shortly pubescent where branches arise, each node with 2-4 branches, the branches 20-30(-50)mm, immediately and again towards the ends 1-3-nate, bearing 3-5 slender spikelets on minutely scabrous delicate pedicels 2-5mm long. *Spikelets* chasmogamous, narrow, violet coloured. *Glumes* sub-equal, hyaline with long delicate often damaged tips, violet coloured below, *lower glume* 10.7-13.5mm, delicately 3-nerved, minutely hairy down mid-nerve, *upper glume* 10.0-12.0mm, 5-nerved, very minutely and sparsely rough between nerves above the mid-point. *Lemmas 5.0-7.0(-7.5) (including callus tuft and tip)* x *(0.45-)0.50-0.70mm wide*, firm, cylindrical, the margins meeting, pubescent, *dark brown* (Munsell 7.5YR 3/2), the body dark brown and minutely pimpled and toothed, the teeth 0.02mm sparse and even over top half to third of lemma, the hairs c. 0.50 x 0.01mm diameter at base, moderately dense at c. 20° to body surface, pinkish white (Munsell 7.5YR 8/2); *callus tuft* including sharp tip 1.8-2.5mm, the hairs very dense and fine, very pale brown (Munsell 10YR 8/3), the *callus scar* 0.27-0.42 x c. 0.10mm wide; *lemma lobes* absent or (0.02-)0.05-0.27mm; *lemma crown hairs* in two tufts in lateral position each of 3-4(-8) hairs exceeding awn base 0.20-0.40(-0.8)mm; *awn* once-kneed, *the bristle falcate*, the *column* (8.5-)9.0-11.5 x *0.27-0.35 (-0.43)mm diameter above articulation*, minutely, moderately densely hairy, the hairs adpressed over whole column and 0.17-0.25mm long, the bristle triangular in section and densely ciliate on the angles, the cilia 0.05mm. *Palea* (3.3-)3.5-4.7 (-4.9)mm, the same texture and hairiness as the lemma on the back, the tip reaching to 0.3mm below the top of the lemma, tip and margins membranous. *Anthers* three, usually 1 larger and 2 smaller, occasionally all equal, when unequal the larger 0.6-2.5(-2.9)mm, the smaller 0.4-2.2(-2.7)mm, when equal 2.1-2.6mm. *Lodicules* two, c. 3.0mm.

WESTERN AUSTRALIA. - Irwin: Northampton, Oct 1898, *Helms* (K.202); Mingenew, Aug 1934, *Holmes* (K.205). Darling: Swan River, *Drummond 961* (K); Kelmscott, Sept 1897, *Helms* (K.204); Moora, in railway enclosure, Sept 1947, *Blake 18049* (K). Eyre: Bremer Bay, 1900, *Wellstead* (K.220).

SOUTH AUSTRALIA. - Eyre Peninsula: Caroona [?Corunna], June 1885, *Cleland S7* (K). Southern Lofty: Beaumont, Oct 1936, *Cleland S39* (K); Hills near Waterfall Gully, *Cleland H.553* (K).

VICTORIA. - Western Volcanic Plains: Mitre Rock near Mt Arapiles, Sept 1960, *Hicks 312* (K). Central: Avenel, Dec 1934, comm. *Sonenberg* (K); Melbourne: Observatory grounds, Domain, South Yarra, Jan 1947, *Morris* (K); Yarra River, *Mueller* (K). Eastern Highlands: Wodonga, sheet 1, Dec 1936, *Black 1190* (K).

TASMANIA. - South East: On Dobson Highway at "fossil-forest" road cutting, 1km east of Macquarie Plains Railway Station, Nov 1966, *Townrow 12* (HO); Macquarie Plains, Dec 1952, *Curtis* (HO); Hobart, Cascades, Dec 1890, *Rodway* (HO), Nov 1905, *Rodway* (HO); Domain, Nov 1905, *Rodway* (HO), Dec 1943, 2 sheets, *Curtis 21* (K), Right hand side of Olympic Pool turnoff, Nov 1967, *Townrow 33* (HO), Dec 1923, *Lucas* (K.492). East: Eight km N of Perth near Launceston, Dec 1968, *Townrow 233* (K); 14 km W of Campbell Town on Cressy road, c. 11km SW of Conara Junction, Dec 1967, *Townrow 128* (HO).

Distribution: South western Australia, South Australia, Victoria, South and Central midlands of Tasmania.

Ecology: In Tasmania, roadsides in comparatively dry open woodland and open scrub mostly between 180-300m altitude above sea level with less than 500mm annual rainfall.

Notes: 1. *S. variabilis* belongs to a group of phenetically related species characterised by lemmas c. 5mm long bearing more or less falcate awns, with only two lodicules per floret instead of the more usual three per floret.

The group, replete with taxonomic difficulties, occurs on the Australian mainland and includes *S. falcata* Hughes a rare member of the Tasmanian flora (see fig. 12) and *S. scabra* Lindley, *S. nitida* Summerhayes and Hubbard, *S. incurva* Hughes, *S. leptophylla* Hughes, and *S. pycnostachya* Bentham, none of which occur in Tasmania.

2. Hughes' cited type material of *S. variabilis* consists of three sheets A, B and C, (A and B each have two specimens) all varying slightly from each other. The specimen she figures (sheet A) (fig.11) has mature lemmas c. 5mm long. The plants on sheet B differ in lemma body length from each other and from those on sheet A. The left hand specimen (sheet B) has immature lemmas c. 7mm long (including callus) while those of the right hand specimen are c. 6mm long and more mature, i.e. more coloured and slightly swollen. The variation of lemma body length with different stages of maturity has yet to be determined for a single plant during one growing season. The A.L.S.O. is identical for plants on both A and B sheets.

3. *S. variabilis* and *S. falcata* have very similar culms and inflorescences, but the type specimens at least are distinguishable on vegetative characters, *S. variabilis* having longer wider leaf blades and *S. falcata* having a basal clump of short stiff, needle-like innovations. Ecological variants occur which are very difficult to place in either taxon. *S. variabilis* growing in dry situations has innovations approaching those in *S. falcata;* the basal needle-like innovations characteristic of *S. falcata* grown in very dry situations, grow out in damper habitats producing plants easily confused with *S. variabilis*.

4. Five specimens of *S. variabilis* and three of *S. falcata* were examined in an attempt to split the material into two distinct taxa, and were segregated on leaf characters including the number of costae per blade, the mode of folding of the blade and the A.L.S.O. The lemmas of the two groups showed considerable overlap in dimensions of several characters, but the *S. variabilis* lemmas tended to have awns with stouter, less twisted columns, shorter or no lemma lobes, shorter callus tufts but longer lemma bodies, and longer broader callus scars than the *S. falcata* lemmas (Appendix 2D). A detailed and extended numerical and/or chemical and cytological evaluation of characters is required to test the relationship of these and other phenetically related taxa.

12. *STIPA FALCATA* Hughes, *Kew Bull., 1921*, p.14 (1921).
(Figure 12; Plate 2, figure 12)
Holotype: New South Wales, Murrumbidgee, *McArthur 141* (K).

Perennial, caespitose; *culms* 0.3-0.5m, 1.0-1.3mm diameter at base, erect, terete, 2(-3) noded; *nodes* ± exserted and glabrous, very minutely downy immediately beneath the nodes otherwise smooth. *Leaf sheaths* finely striate, glabrous or sub-retrorse-pubescent below, outer margins ciliate, the cilia c. 0.2mm, with a few hairs up to 1mm in the position of auricles; *ligule* up to 1mm, oval, densely minutely ciliate; *blades setaceo-convolute*, the innovation blades 90-180 x c. 0.3mm diameter, the cauline blades 40-60 x 0.4-0.6mm diameter, *abaxial surface* especially of the innovations minutely antrorse-scabrous, whitish green, *adaxial surface* deeply grooved with *5-7 ribs*, scabrid hairy, *A.L.S.O.* of ascending macrohairs and antrorse prickle hair hooks both moderately dense, the macrohairs (35-)50-140 x 7-14μ diameter at base, long and slender with a collar-like base, the prickle hair hooks 20-30 x 1-2μ diameter at base, the costal epidermal long cells c. 90 x 4μ wide with thickened, straight walls. *Panicle* up to 250 x 20-30mm wide, primary axis smooth or minutely scabrous, subtriquete, c. 7-noded, the lower nodes c. 30mm apart, smooth and hairless, each node with 1-3 branches, the branches slender, minutely scabro-pubescent, immediately 2-nate, then 1-3-nate towards the ends, bearing 1-3(-5) slender spikelets on minutely scabrous delicate pedicels 6-16mm long. *Spikelets* chasmogamous, narrow, a little gaping. *Glumes* subequal, acuminate, delicate, violet below and hyaline above, very minutely

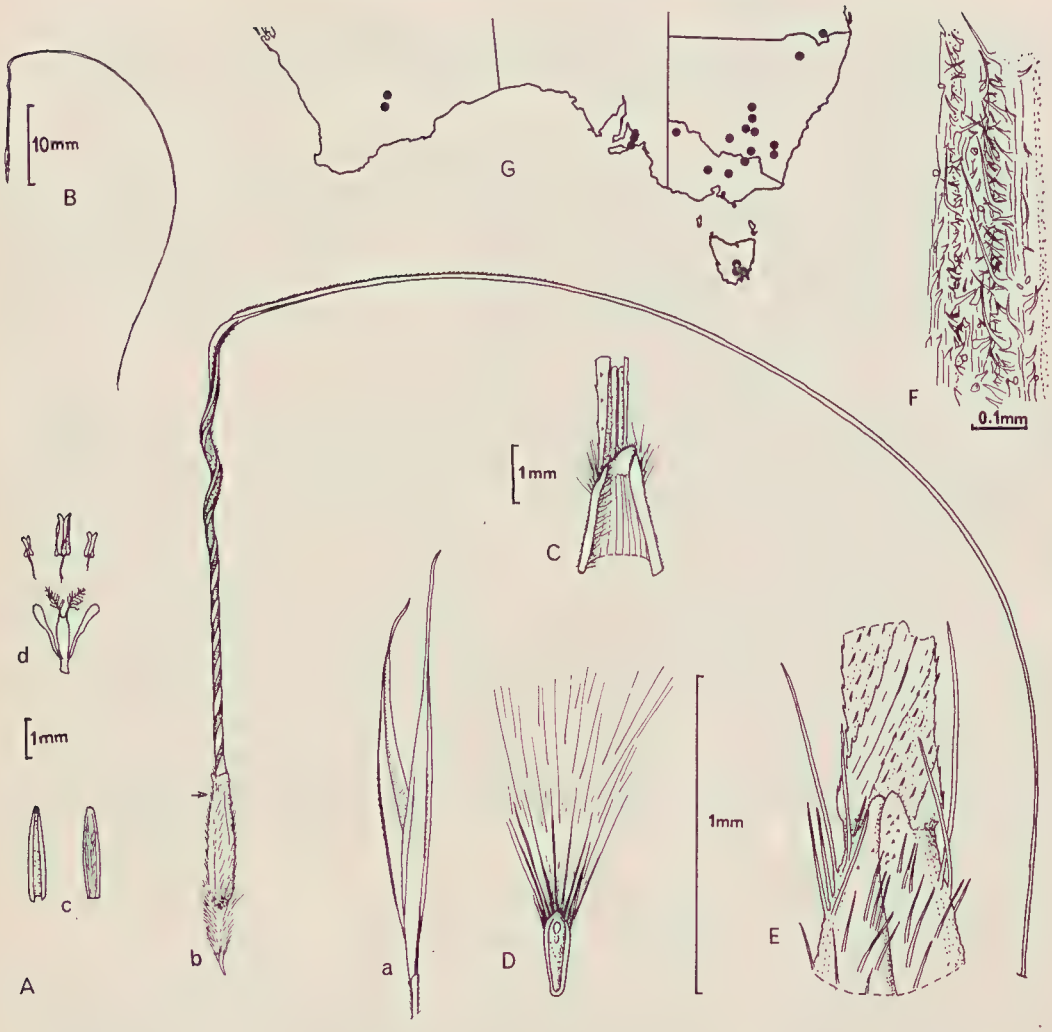

FIG. 12. - *Stipa falcata* Hughes, "Burbidge 1817" (K) (matched with type specimen). Explanation as for figure 1 (p.236) except: C. Ligule (blade 2 from culm base) x7.5 F. Tracing of micrograph of part of area shown in Plate 2, fig. 12.

scabrous on middle of central nerves and between nerves above the mid point, *lower glume* 10.5-17.0 (-19.0)mm, delicately 3-nerved, *upper glume* 10.0-14.1(-15.2)mm, delicately 5-nerved. *Lemmas* 5.9-6.8 (including callus tuft and tip) x 0.5-0.8mm wide, firm, narrowly ovate, the margins gaping over developing caryopsis, sparsely-moderately pubescent, dark reddish brown (Munsell 5YR 3/4), the body beneath the hairs dark brown (Munsell 7.5YR 4/4), smooth, very minutely hairy on upper 1/5 of abaxial surface with hairs c. 0.01mm, the body hairs c. 0.36 x less than 0.01mm diameter at base, sparse, at angle of 35° to body surface, white (Munsell 2.5YR 8/2); *callus tuft* including sharp tip (1.8-)2.1-2.8mm, white like the body hairs, the *callus scar* 0.25-0.37 x c. 0.07mm wide; *lemma lobes* 0.12-0.32mm, smooth, oval, entire; *lemma crown hairs* in lateral tufts of 1-3 hairs on either side, exceeding awn base by 0.1-0.5mm; *awn* once-

kneed, the bristle falcate, the *column* 8.5-12.5 x *0.25-0.32 mm diameter* above articulation, minutely moderately densely hairy over whole column and on the bristle angles, the hairs c. 0.05mm. *Palea* (2.3-)3.6-4.4mm, a thin membrane with a membranous tip reaching to 0.5mm below top of lemma, minutely hairy on the back between the veins. *Anthers* three, one large (0.9-)1.2-2.5mm and two smaller 0.5-2.1mm. *Lodicules* two, c. 1.5mm.

WESTERN AUSTRALIA. - Coolgardie: Coolgardie, Aug 1897, *White* (K.200); Kalgoorlie, Sept-Nov 1909, *Maiden* (K.495).

SOUTH AUSTRALIA. - Eyre Peninsula: Kinchina, Sept 1922, *Cleland S12* (K); Southern Lofty: Beaumont, Oct 1926, *Cleland S3911* (K); Milang, Nov 1896, *Menzel* (K.442); MacLaren Vale, Oct 1925, *Cleland S31* (K); Encounter Bay, Aug 1924, *Cleland S29* (K), Sept 1924, *S28* (K), Sept 1927 (H.133).

QUEENSLAND. - Darling Downs: Three miles from Ballandean, Nov 1944, *Clemens 44657* (K).

NEW SOUTH WALES. - South Western Slopes: Corowa, Dec 1946, *Moore 474* (K; CANB. 13232); Roadside about 16 km N of Albury, Oct 1933, *Rodway* (K; NSW. 1201); Wagga, Oct 1889, *Fletcher* (K); Cootamundra, per Glenfield Veterinary Research Station, Oct 1932, Anonymous (K.517). North Western Slopes: Plains, near Baradine, Oct 1899, *Forsyth* (K. 491). Central Western Slopes: Temora, Oct 1915, *Dwyer* (K.441), Oct 1912, *Elliot* (K. 518); Bowan Park near Cudal, Oct 1906, *Blakely* (K.510); Cowra, Sept 1913, *Breakwell* (K.443). Southern Tablelands: Black Mountain, stony slopes, dry sclerophyll forest, Nov 1945, *Hartley* (K; CANB. 124); Uriarra Crossing, Murrumbidgee River, Jan 1948, *Burbidge 1809, 1817* (K); Open eucalypt forest, Oct 1960, *McKee 7492* (K); Open grassland, April 1947, *Browne*, (K; CANB. 13230); Murrumbidgee, *McArthur 141* (K). North Western Slopes: Warialda, Jan 1932, *Vickery* (K; NSW 18447).

VICTORIA. - Little Desert: Nov 1957, *Hicks 110A* (K). Western Highlands: Inglewood, Sept 1929, *Sonenberg* (K). Eastern Highlands: Euroa, on main road to Albury, Oct 1933, *Rodway* (K; MEL. 21). Near Mount M'Ivor, *Blandowski* (K).

TASMANIA. - East: About 11 km SW of Conara Junction on Cressy Road, 16 km W of Campbell Town, Dec 1967, *Townrow 127* (HO); Brighton, Nov 1900, *Rodway* (HO); Richmond, Oct 1971, *Townrow 252* (HO); 3 km W of Sorell/Orielton road on road to Richmond, Nov 1967, *Townrow 72* (HO).

Distribution: Western Australia (goldfield area), South Australia (Adelaide), central Victoria, south central New South Wales, Tasmania (rare).

Ecology: In Tasmania, confined to roadsides in very dry open scrub.

Notes: 1. *S. falcata* has been much confused with both *S. variabilis* and with *S. scabra* Lindley (1848), by botanists who have not had recourse to the type material. *S. falcata* is distinguishable from *S. variabilis* (as described under *S. variabilis*) but its distinction from *S. scabra* is far from clear. Lindley's type specimen of *S. scabra* - "New South Wales, Bogan River, 32°S 147°E. *Mitchell 125*" has been mislaid in the Botany Department Herbarium of Cambridge University (Dr. Max Walters *pers. comm.*). The type material at Kew is fragmentary and consists of a few lemmas and damaged glumes taken from *'Mitchell 125"*.

Hughes (1921) cites specimens from Western and South Australia and Queensland in addition to the type from New South Wales. Of these I have examined *"Koch 371"*, "Elder Exploring Expedition", and "Gawler River, *Mueller*" from South Australia, and "Fraser's Range, *Dempster*" from Western Australia. Only Mueller's specimen possibly matches the Kew Lindley type material and its lemmas are very immature which makes positive identification difficult. The others apparently belong to a single taxon but differ from the Kew Lindley type in lemma characters, and from Lindley's description in vegetative characters, having long, glabrous, almost pungent pointed blades. I suggest that *S. scabra sensu* Hughes is not the same as *S. scabra sensu* Lindley.

Revised Taxonomy of *Stipa* in Tasmania

If one accepts as representing *S. scabra sensu* Lindley a specimen collected from New South Wales "Wyngan, Nov 1912, *E. Breakwell*" which has lemmas exactly matching the Kew Lindley type lemmas of *S. scabra*, and which agrees with Lindley's description of "leaves scabrid hairy and involute, culms short and pubescent nodes, ligules ciliolate and oblong", then *S. falcata* differs from *S. scabra* in the hair ornament of the abaxial leaf surfaces of the innovations. Whereas in *S. falcata* the blades have an indumentum of coarse ascending hairs 0.2mm long, while the sheaths are covered with retrorse minute hairs 0.05mm long, appearing scabrid but not obviously hairy, in *S. scabra* both blades and sheaths are coarsely obviously retrorse-hairy with hairs more or less the same length.

Further work is needed to sort out the *S. falcata/S. scabra* complex in both the Australian and the Kew collections.

EXCLUDED NAMES

1. *S. pubescens* R. Brown, *Prodr.*, p.174 (1810) - see note under *S. pubinodis*.
2. *S. elegantissima* Labillardière, *Fl. Nov. Holl.*, 1, p.23 (1805). Labillardière recorded the habitat of this species as Capite Van Diemen. J.H. Willis in *Muelleriana*, 1, p.136 (1967) referred to Labillardière's confusion of habitat labels "Capite Van Diemen" (Tasmania) and "Terra Van Leuwin" (Western Australia) in the case of *Leptospermum glaucescens*, a West Australian species ascribed to Tasmania by Labillardière. It is apparent that a similar mistake was made in the labelling of *Stipa elegantissima* which does not occur in Tasmania.
3. *S. laeviculmis* Nees in Lehmann, *Pl. Priess.*, 2, p.99 (1846). Lehmann (1846) suggested that this taxon be ignored because the type specimen "In insula Van Diemen?" is of uncertain locality.
4. *S. aphanoneura* Hughes, *Kew Bull., 1921*, p.25 (1921). Type: Kent's Group, *Brown 6202* (K). I have examined two sheets labelled "Kent's Group, *Brown 6202*" one at K, the other at BM. The specimen at K with very immature inflorescences and underdeveloped lemmas is practically indeterminable. Its A.L.S.O. most closely resembles that of the type of *S. clelandii* Summerhayes and Hubbard (fig. 8F) but its lemmas although closely similar to those of *S. clelandii* in dimensions, differ in hair crown length and density and hairiness of the awn. The specimen at BM I identify as immature *S. flavescens*.

DISCUSSION

It has been established that the following native *Stipa* species occur in Tasmania - *S. aphylla, S. flavescens, S. nervosa* var. *neutralis, S. mollis, S. semibarbata, S. pubinodis, S. stuposa, S. stipoides, S. variabilis, S. falcata, S. bigeniculata,* and *S. clelandii,* and that *S. aphylla* and *S. stuposa* are endemic species.

From my examination of types of about 55 taxa (K) I suggest tentatively that Australian *Stipae* may be grouped on morphological characters into eight series (unpublished drawings and data of types and/or matched specimens) which differ from Hughes' (1921) subgeneric groups:

1. *S. aphylla, S. muelleri, S. elegantissima, S. tuckeri, S. verticillata, S. ramosissima, ? + S. acrociliata* and *S. platychaeta.*
2. *S. nervosa, S. nervosa* var. *neutralis, S. pubinodis, S. pubescens, S. nivicola.*
3. (a) *S. compressa, S. macalpinei.*
   (b) *S. hirsuta, S. eriopus, S. fusca, S. eremophila.*
4. *S. flavescens, S. tenuiglumis.*
5. (a) *S. aristiglumis, S. bigeniculata.*
   (b) *S. puberula, S. brachystephana, S. oligostachya, S. blackii, S. tenuifolia, S. setacea.*
   (c) *S. stuposa, S. clelandii.*

6. *S. nobilis, S. hemipogon, S. mollis, S. semibarbata, S. plumigera, S. densiflora, S. drummondii.*
7. (a) *S. variabilis, S. trichophylla, S. incurva.*
   (b) *S. falcata, S. scelerata (=S. nodosa), S. nitida, S. leptophylla, S. pycnostachya.*
8. *S. stipoides, S. juncifolia.*

The Tasmanian flora contains representative species of all but one of the above series and so represents a cross section of the native Australian *Stipae*. The Tasmanian species are therefore admirably suited for selection as a representative group for preliminary investigation as forerunner of an extended experimental taxonomic study of all the Australian *Stipae*, pending the completion of a classical revision of Australian *Stipae* which has been undertaken by Dr. J.W. Vickery (*pers. comm.*, November 1974).

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APPENDIX I

INDEX TO COLLECTORS

The numbers in italics are the collectors' specimen numbers, the numbers in parentheses ( ) refer to the corresponding species as numbered in the text e.g. (1) refers to *S. aphylla*, (2) refers to *S. flavescens* etc. The other numbers refer to the number of specimens of the particular species. Tasmanian specimens are indicated by the suffix *.

Andrews 1 unnumbered (2).
Archer 1 unnumbered (3); 1 unnumbered* (6); 1 unnumbered* (10).
Aston 1 unnumbered (5).
Bailey 2 unnumbered (4).
Black *1193* sheet 1* (5); *1190* (11).
Blake *18277** (1); *18437** (2); *17323** (4); *13915*, *4638* (5); *18278** (6); *18324** (9); *18280**, *18322** (10); *18049* (11).
Blakely 1 unnumbered (4); 1 unnumbered (12).
Blandowski 1 unnumbered (12).
Boorman *431* (3).
Breakwell 1 unnumbered (12).
Brown *6202*, 1 unnumbered (2); *6205* (3); *6204*(4).
Browne 1 unnumbered (12).
Burbidge *13641*, *16575*, *2517*, *2551*, *3184** (4); *2390**, *2935** (5); *25116**, *2954**, *?3189** (6); *2934**, *3185**, *3186** (9); *3183** (10); *1809*, *1817* (12).
Cambage *3068* (7).
Campbell 1 unnumbered (4).
Carne 1 unnumbered (4).
Cleland 1 unnumbered (2); *H61*, *72*, *H98*, *H487*, 3 unnumbered, 1 unnumbered* (3); *S4*, *S18*, *S25*, 1 unnumbered (4); *S16* (6); 2 unnumbered (7); *S40* (8); 1 unnumbered (10); *S7*, *S39*, *H553* (11); *S12*, *S28*, *S29*, *S31*, *S3911*, 1 unnumbered (12).
Clemens *44760* (5); *44657* (12).
Collie 1 unnumbered (2).
Constable *NSW 52366* (10).
Craven *614* (10).
Curtis *128** (1); *20**, *130**, 2 unnumbered* (2); *22**, 7 unnumbered* (3); *18A**, *131** (5); *18B**, *120**, *124**, *129**, 1 unnumbered* (6); *126** (7); *125**, *127** (9); *17**, 1 unnumbered* (10); *21**, 1 unnumbered* (11).
Davies 1 unnumbered (2); 2 unnumbered (4).
Davis and Davis *10578** (6).
Dorrien Smith 1 unnumbered (4).
Drummond *959* (2); *961* (11).
Dwyer 1 unnumbered (12).
Eardley 1 unnumbered (7).
Elliot 1 unnumbered (12).
Fletcher 1 unnumbered (12).
Forsyth 1 unnumbered (12).
French *28130* (2).
Gunn *996**, 1 unnumbered (2); *1452** (3); *1480** (4); *588**, *996**, *996** (6); *1453**, *1480** (9); *1490** (10); *1487** (11).
Hannaford 2 unnumbered (4).
Hartley 1 unnumbered (12).
Harvey 1 unnumbered (4).
Helms 2 unnumbered (11).
Hicks *312* (11); *110A* (12).
Hilton *1170* (6).
Holmes 1 unnumbered (11).
Home 1 unnumbered* (9).
Ising 1 unnumbered (4); 1 unnumbered (6).
Jackson 1 unnumbered (2).
Johnson 1 unnumbered (3).
Koch 1 unnumbered (4).
Kuchel 1 unnumbered (4).
Labillardière 1 unnumbered * (2).
Llotsky 1 unnumbered * (9).
Lucas 1 unnumbered * (10; 1 unnumbered * (11).
Maiden *K495* (12).

Maiden and Cambage *K460** (9).
McArthur *141* (12).
McKee *7492* (12).
Meeresnäke 1 unnumbered (3).
Menzel 1 unnumbered (12).
Moore 1 unnumbered* (3); *474* (12).
Morris, D.I. 1 unnumbered (8).
Morris, P.F. 1 unnumbered (11).
Morrison 1 unnumbered (3); 1 unnumbered (6).
Mueller 1 unnumbered* (6); 1 unnumbered (10); 1 unnumbered (11).
Muir *519*, *1956* (4).
Palmer 1 unnumbered (4).
Paterson 1 unnumbered (2).
Patton 1 unnumbered (7).
Phillips and Vickery *001268** (5); 1 unnumbered (6); *001274** (10).
Pullen *4126* (3); *3735*, *3955* (7).
Robb 1 unnumbered (10).
Robbins 1 unnumbered (5).
Robertson *529* (3).
Rodway *995**, 2 unnumbered (1); *25**, *H117* , 1 unnumbered (2); 1 unnumbered, 1 unnumbered* (3); 2 unnumbered* (4); 1 unnumbered, 1 unnumbered (5); *10577**, 2 unnumbered* (6); *2058**, 1 unnumbered (9); *27**, *2057**, 1 unnumbered* (10); *25**, 3 unnumbered* (11); 2 unnumbered, 1 unnumbered* (12).
Sonenberg 1 unnumbered (2); 3 unnumbered (3); 1 unnumbered (4); 2 unnumbered (6); 1 unnumbered (7); 1 unnumbered (10); 1 unnumbered (11); 1 unnumbered (12).
Stoward *935* (12).
Symon *141* (2).
Thomas 1 unnumbered (7).
Tilden *754* (10).
Townrow *4B**, *24**, *77**, *147**, *205**, *246**, *297**, *298**, 1 unnumbered* (1); *15**, *16**, *28**, *41**, *42**, *55**, *56**, *83**, *94**, *112**, *144**, *157**, 1 unnumbered * (2); *9**, *57**, *63**, *70**, *71**, *75**, *81**, *82**, *110**, *139**, *158**, *171**, *180**, *187**, *243**, 1 unnumbered (3); *166**, *175**, *248**, (4); *3**, *18a**, *19**, *76**, *91**, *103**, *104**, *114**, *124**, *137**, *165**, *181**, *196**, *197**, *245**, (5); *1**, *5a**, *27**, *39**, *58**, *60**, *62**, *67**, *79**, *80**, *102**, *107**, *111**, *130**, *135**, *138**, *146**, *173**, *176**, *178**, *191**, *193**, *205**, *247**, 1 unnumbered* (6); *96**, *115**, *162** (7); *7**, *35**, *44**, *50**, *69**, *86**, *95**, *98**, *105**, *116**, *131**, *164**, *172**, *228**, *249**, 2 unnumbered* (9); *6**, *54**, *54a**, *250** (10); *12**, *33**, *128**, *233** (11); *72**, *127**, *252** (12).
Vickery 1 unnumbered, 1 unnumbered* (3); 1 unnumbered (5); *8565** 1 unnumbered* (6); *7491** (10); 1 unnumbered (12).
Wellstead 1 unnumbered (11).
White *8336** (5); 1 unnumbered (12).
Williamson *692* (6).
Willis 1 unnumbered (2).

APPENDIX 2

TABLE A

TASMANIAN *STIPA* SPECIES. COSTAL CHARACTERS OF THE ADAXIAL LEAF SURFACE - SILICA BODIES

Observations and measurements made on scanning micrographs x140:

Silica bodies

Species	Frequency	Dimensions μ length x diameter	Shape	Arrangement
1. *S. aphylla*	None seen			
2. *S. flavescens*	Very abundant	15-20 x 7-10	Dumbbell, some nodular [S_4]*	In obvious rows between and within rows of epidermal long cells. 3-9 in a row alternating with short cells with prickle hair hooks above and below.
3. *S. mollis*	None seen			
4. *S. semibarbata*	None seen			
5. *S. nervosa* var. *neutralis*	Abundant	10-18 x 7-10	Dumbbell, some irregularly oval [S_4]	In irregular rows, alternating with long cells macrohairs and prickle hairs.
6. *S. pubinodis*	Scattered	15-20 x 10-15	Irregularly oval with raised margins, approaching [S_4]	In rows with long cells, often alternating regularly with macrohairs: long cell, macrohair, long cell, silica body, long cell.....
7. *S. bigeniculata*	Abundant	15-30 x 10-15	Dumbbell, some nodular [S_4]	In separate rows of silica bodies and short cells, and in rows with prickle hair hooks and short cells.
8. *S. clelandii*	Moderately frequent	20-30 x c.15	Dumbbell, some irregular [S_4]	Obscured by wax platelets.
9. *S. stuposa*	Abundant	15-20 x c.10 c.30 x c.10	Dumbbell [S_4]	In rows alternating within the row with epidermal long cells.
10. *S. stipoides*	None seen			
11. *S. variabilis*	Scattered singly	10-15 x 7-10	Dumbbell [S_4]	Alternating with long cells.
12. *S. falcata*	None seen			

* Prat's classification (1960, 1968)

TABLE B

DIFFERENCES BETWEEN *S. PUBINODIS* TRIN. AND RUPR. AND *S. PUBESCENS* R.BR.

Character	*S. pubinodis*	*S. pubescens*
A.L.S.O.	Moderately dense fine macrohairs 70-280 x 10-15μ diam., plus antrorse prickle hairs 20-43 x 10μ diam. at base on the rib surfaces, macrohairs strongly ascending, becoming shorter and finer on successive blades; trough between the ribs very narrow.	Dense minute antrorse prickle hair hooks 15-25μ long on the rib surfaces; dense minute tapering macrohairs 35-46 x 7μ diam. at base in wide troughs between the ribs, the hairs retrorse and swollen based.
Ligule	Lower ligules up to 2mm long, hard, finger-nail shaped (sometimes lop-sided), ciliate margined and minutely hairy on the back; upper ones shorter with fimbriate margins.	Minutely ciliate-margined, erose membrane about 0.5mm long.
Glumes	Very minutely sparsely hairy between the veins; glume margins hairless, the tips torn.	Hairy on and between the veins; lower glume acute with densely ciliate margins; upper glume emarginate, margins smooth.
Lemma	Surface of upper 1/3 minutely dentate, the teeth irregularly spaced and moderately dense, c. 0.03mm long.	Surface very minutely bumpy in hairless region below the awn.
Body hairs	Sparse above, dense below, 0.9 x 0.02mm, white to reddish-yellow.	Sparse, 0.5-1.0mm long x 0.01mm diam., white.
Awn hairs	0.26 x 0.02mm, moderately dense on lower column, very dense on upper column; bristle with 8 rows of hairs 0.1mm long.	0.1 x 0.01mm, moderately-very dense over whole column, bristle with 2 rows of hairs 0.01mm long.
Callus tuft	3.5-4.6mm, reddish yellow-strong brown.	3.0-3.5mm, pale yellow.
Palea	Up to 8.8mm long, equalling lemma, acute, with a horny central yellowish portion similar in texture to the lemma, and relatively broad thinly membranous margins.	About 5.2mm long, about 3/4 length of lemma, a delicate, hyaline, blunt-tipped membrane entirely enclosed in the lemma.
Lodicules	3: 2 ovate above and swollen below, c. 3.0mm long, 1 linear, c. 2.0mm long.	3 leaf-shaped: 2 more or less truncate, c. 1.0mm long, 1 acute, c. 0.6mm long.

TABLE C

A COMPARISON OF *S. STUPOSA* WITH *S. CLELANDII* AND *S. BLACKII*

based on spikelet measurements and leaf characters from the type specimens

Character	*S. stuposa*	*S. clelandii*	*S. blackii*
A.L.S.O. µ			
Macrohairs	Sparse-frequent, 100-450 long x 15-20 base diameter.	Frequent, 70-210 long x c.15 base diameter.	Dense macrohairs, grading to prickle hairs, 20-70 x 10-15 diameter.
Prickle hair hooks	Frequent, 20-30 x 10-15 diameter.	Very few, 20-30 x c. 10 diameter.	None.
Ligule mm	Ciliate membrane, 0.5	Ciliate membrane, 0.7	Ciliate membrane, 0.4
Glumes approx. length mm			
Lower	21.0 (torn)	19.0 (torn)	15.5
Upper	17.0	12.5 (torn)	11.5
Lemma mm			
Colour	Dark reddish brown. Munsell 5 YR 3/4	Yellowish brown. Munsell 10 YR 5/4	Reddish-light reddish brown. Munsell 5 YR 4/3
Body and callus	9.0-10.0 x 1.0	7.2-7.7 x 1.3	6.3 x 1.2
Callus tuft	3.2-3.5	2.5-3.0	2.5
Callus scar	0.64 x 0.13	0.63 x 0.13	0.63 x 0.20
Crown hairs	2.0-3.0	2.5-5.0	3.0-3.8
Body hairs	Moderately dense, 1.0 x 0.01, very pale brown.	Very dense, 1.1 x 0.02, pale yellow.	Moderate to very dense, 1.5 x 0.01, yellow.
Lobes	0.20-0.12	Absent.	Absent.
Awn Column mm			
Length	19-21	14-21	14-16
Diameter	0.32	0.32	0.32
Length to 1st knee	12-15	9-12	6-8
Hair ornament	Moderately dense, 1.0-0.7	Dense, 0.25-0.12	Dense and adpressed, c.0.25
Palea mm	Horny on back like lemma, 6.8	Slightly thinner than lemma, 5.0	Slightly thinner than lemma, 4.3

TABLE D

RANGE OF VARIATION IN DIMENSIONS OF DISTINGUISHING LEMMA CHARACTERS found in five specimens of *Stipa variabilis* and three specimens of *Stipa falcata* segregated on leaf blade characters.

The figures in square brackets refer to the corresponding dimensions in *S. variabilis* type specimen A, and *S. falcata, Burbidge 1817*, the specimen matched with the type specimen of *S. falcata*.

	S. variabilis	*S. falcata*
Blade folding	involute	setaceo-convolute
Number of costae/blade	9+	5-7
A.L.S.O.	see fig. 11, p.168	see fig. 12, p. 175
Lemma awn column diameter mm	0.27-0.43 [0.36-0.43]	0.25-0.32 [0.25-0.33]
Lemma lobes mm	(0.02-)0.05-0.27 [absent]	0.125-0.325 [0.15-0.28]
Callus scar mm	0.275-0.420 x c. 0.10 [0.38 x c. 0.10]	0.250-0.375 x c. 0.07 [0.25 x c. 0.07]

APPENDIX 3

Notes and drawings of Australian mainland species *S. nervosa*, *S. pubescens* and *S. blackii* are appended for comparison with those of the Tasmanian *S. nervosa* var. *neutralis*, *S. pubinodis* and *S. clelandii* respectively, (see text pp. 251, 254, 259).

The main points of comparison are:

1. *S. nervosa* is shorter in lemma body, callus tuft, awn column and palea than the var. *neutralis*, and has two lodicules not three. The A.L.S.O. of both are essentially similar.
2. *S. nervosa* var. *neutralis* differs especially in ligule and A.L.S.O. characters from *S. pubinodis* and *S. pubescens*.
3. *S. pubinodis* differs from *S. pubescens* in palea, ligule and A.L.S.O. characters.
4. *S. blackii* occupies an intermediate position between *S. clelandii* and *S. stuposa* regarding lengths of glumes, lemma bodies and awn columns, and hairiness of paleas. (See Appendix 2C).

S. NERVOSA Vickery
(Figure 13; Plate 2, figure 13)
Floret and leaf blade characters
"Pennant Hills, Dec 1953, *Vickery*" (K) matched with type specimen.

Blades involute, up to 3.5mm wide at base.
A.L.S.O. of sparse more or less ascending macrohairs and moderately dense slightly antrorse prickle hairs and prickle hair hooks, the macrohairs up to c. 300 x 40µ diameter at the swollen bases, finely tapering, the prickle hairs up to c. 50µ, mostly arising straight from the rib surface.
Lemma dark brown (Munsell 10YR 3/3), margins overlapping to base.
Lemma body 7.7-8.8 x 0.7-0.9mm (including callus), dark reddish brown (Munsell 5YR 2/2) minutely hooked above, smooth-minutely pimpled beneath the hairs below, the body hairs c. 0.8 x 0.02mm diameter at base, sparse, erect, adpressed, yellow (Munsell 2.5Y 6/8).

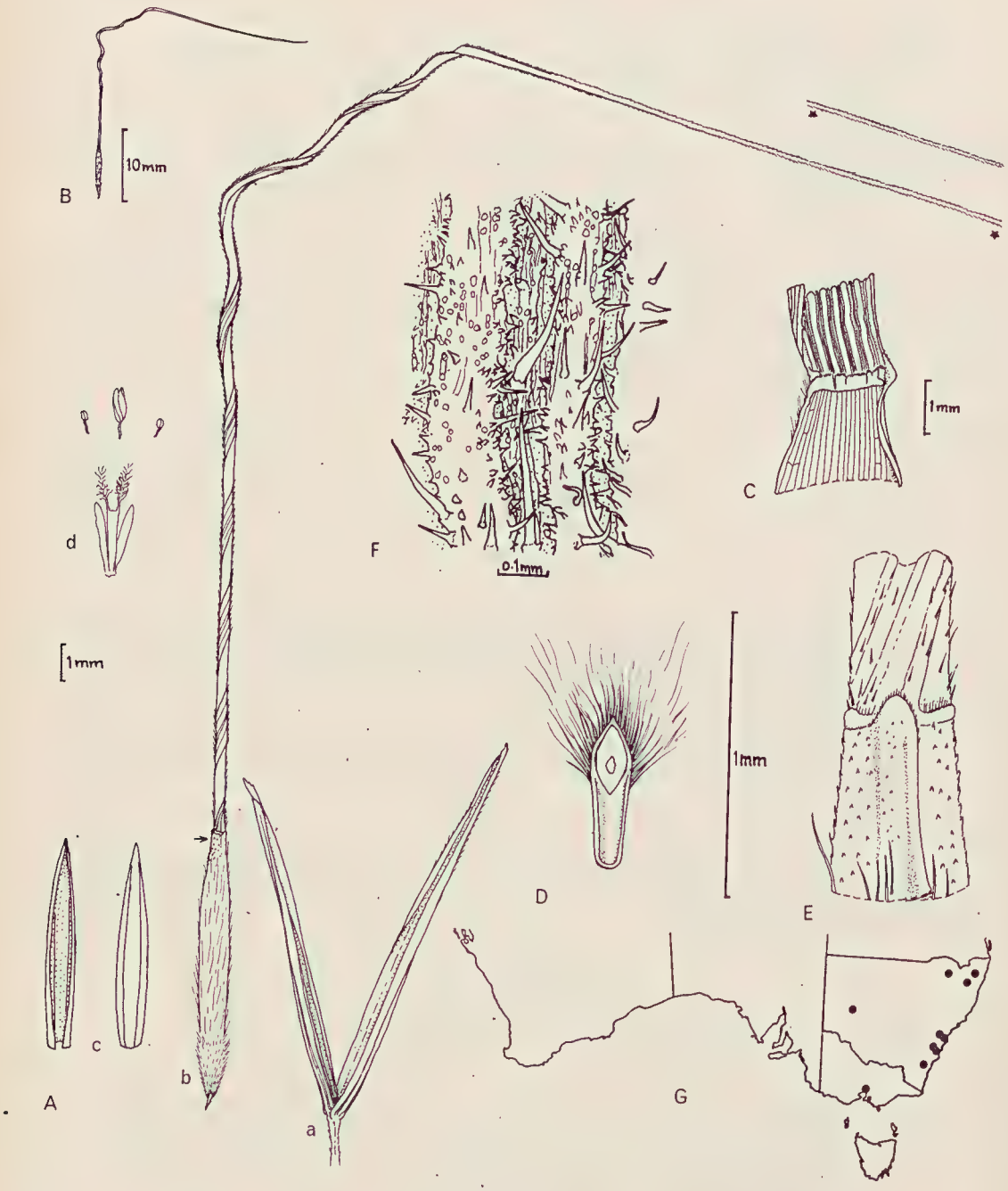


FIG. 13. - *Stipa nervosa* Vickery, "Dec. 1953, *Vickery*" (K) (matched with type specimen). Explanation as for figure 1 (p.236) except: C. Ligule (blade 3 from culm base) F. Tracing of micrograph of part of area shown in Plate 2, fig. A.

Callus tuft and tip c. 2.0mm, brownish yellow-yellow (Munsell 10YR 6/8-2.5Y 8/6).
Callus scar 0.51 x 0.15mm.
Lemma lobes c. 0.10mm, oval, minutely ciliate.
Lemma crown hairs absent.
Awn twice kneed; the column c. 29 x 0.38mm diameter above articulation and c. 15mm to first knee, sparsely hairy to the end of the bristle, the hairs c. 0.05mm becoming denser on the upper column between the 'knees'.
Palea 5.8-6.2mm, hyaline tip reaching to 0.2mm below top of lemma, entirely enveloped by lemma, hairless, slightly thinner than lemma.
Anthers three, of which two 0.2mm, one 0.9mm.
Lodicules two, 2mm.

S. PUBESCENS Brown
(Figure 14; Plate 2, figure 14)
Floret and leaf blade characters
"Brown 6203" (K) type specimen.

(Single value measurements are necessarily taken from a single spikelet due to the inadvisability of mutilating the type specimen).
Blades involute.
A.L.S.O. of abundant antrorse prickle hair hooks on the costal surfaces, and dense retrorse macrohairs between the costae; the prickle hair hooks 15-25μ , the macrohairs 35-46 x c. 1μ diameter at base, strongly tapering and swollen based.
Lemma dark reddish grey (Munsell 5YR 4/2), margins overlapping.
Lemma body 10.3 x 1.0mm (including callus), reddish brown (Munsell 5YR 4/4) beneath the hairs, minutely rugose below the awn in hairless region, the body hairs 0.5-1.0 x 0.01mm diameter at base, sparse, almost vertical to body, white (Munsell 5YR 8/1).
Callus tuft and tip 3.0-3.5mm, pale yellow (Munsell 2.5Y 8/4).
Callus scar 0.64 x 0.18mm.
Lemma lobes absent, lemma margin free above for c. 0.1mm.
Lemma crown hairs absent.
Awn twice kneed; the column c. 47 x 0.5-0.6mm diameter above articulation and c. 35mm to first knee, moderately-very densely hairy, the hairs 0.1 x 0.01mm diameter at base, continuing along the bristle angles.
Palea 5.2mm, membranous with a hyaline tip reaching to 2.1mm below top of lemma, completely enclosed by lemma.
Anthers three each 5.2mm.
Lodicules three equal of which two are more or less truncate, one acute.

S. BLACKII Hubbard
(Figure 15; Plate 2, figure 15)
Floret and leaf blade characters
"Jamestown, *Black 2"* (K) type specimen.

(Single measurements are necessarily taken from a single spikelet due to the inadvisability of mutilating the type specimen).
A.L.S.O. of moderately dense intergrading more or less antrorse macrohairs and prickle hairs 2-70μ, finely tapering from somewhat swollen bases, the larger hairs wavy, the shorter hairs peg-like.
Lemma reddish brown to light reddish brown (Munsell 5YR 4/3-6/4); margins inrolled and meeting; very hard.
Lemma body 6.3 x 1.2mm (including callus), reddish brown and minutely densely pimpled under the hairs, the pimples c. 0.025mm diameter, the body hairs c. 1.5 x 0.01mm diameter at base, moderate to very dense, acutely angled to body at 10°-15°, yellow (Munsell 2.5Y 8/4).
Callus tuft and tip c. 2.5mm, yellow (Munsell 2.5Y 8/4).
Callus scar 0.625 x 0.20mm.

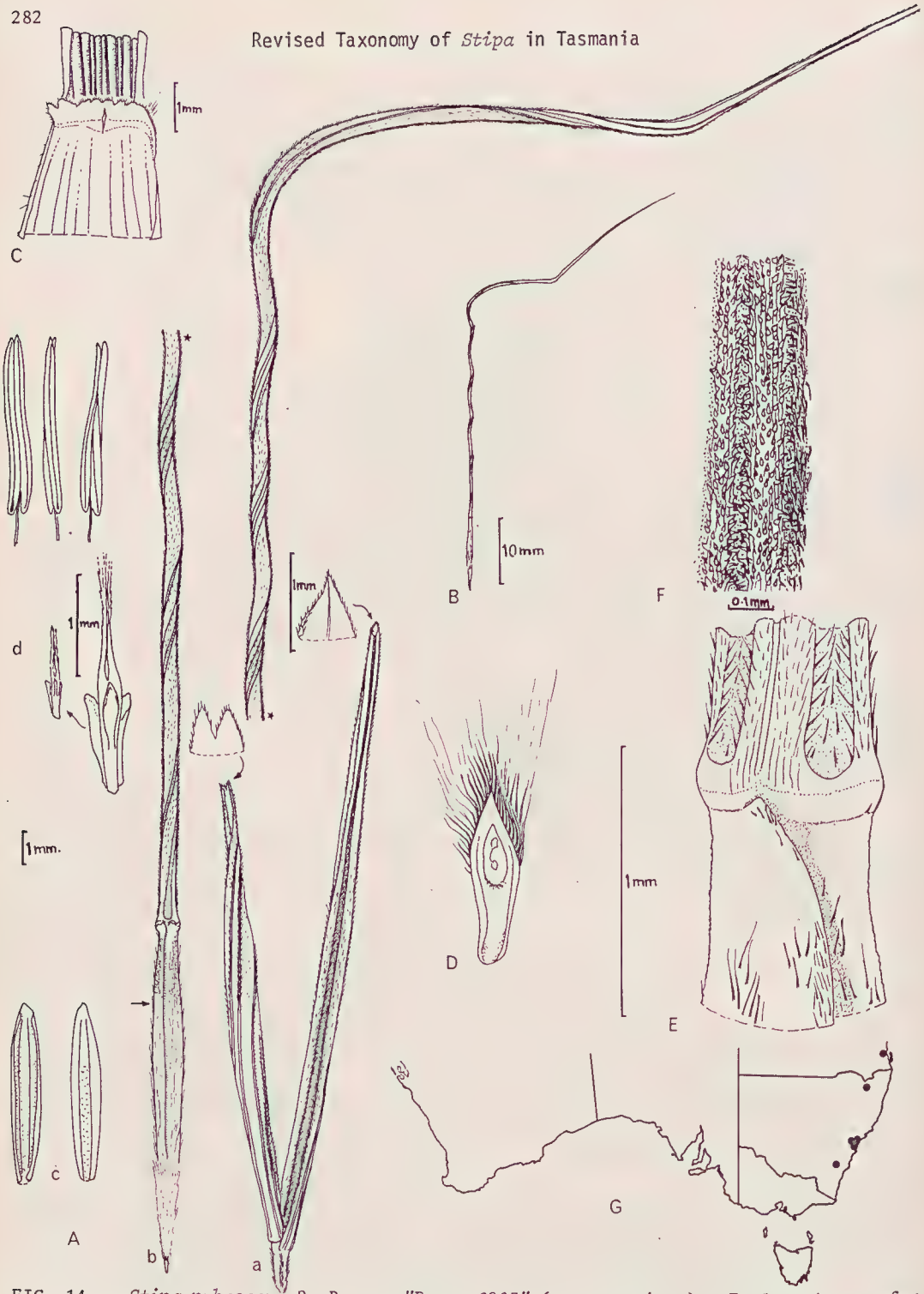


FIG. 14. - *Stipa pubescens* R. Brown, *"Brown 6203"* (type specimen). Explanation as for figure 1 (p.236) except: A. a. glumes (tips x15); C. Ligule (blade 2 from culm base); F. Tracing of micrograph of part of area shown in Plate 2, fig. B.

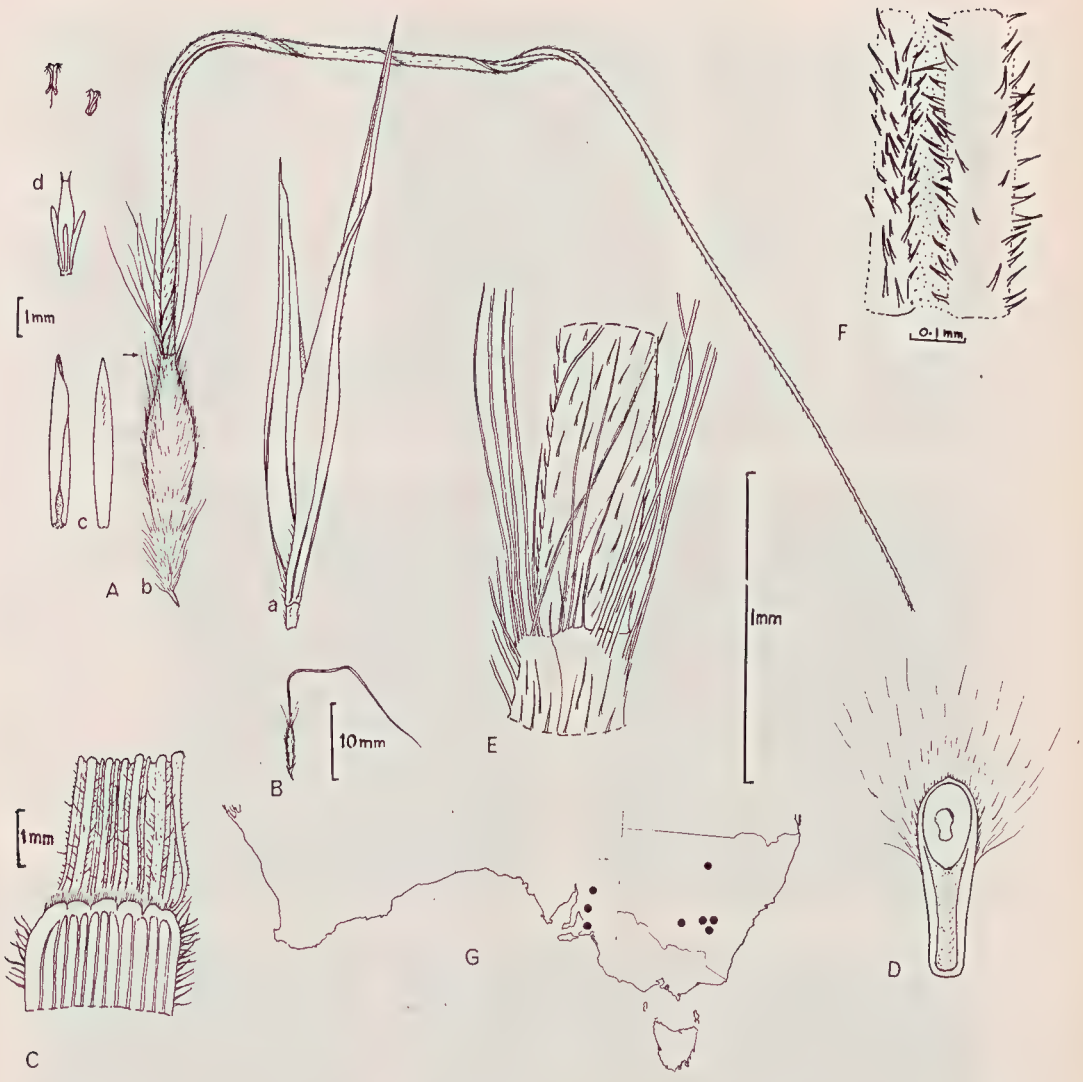


FIG. 15. - *Stipa blackii* Hubbard, *"Black 2"* (K) (type specimen). Explanation as for figure 1 (p.236) except: C. Ligule (blade 2 from base) F. Tracing of scanning micrograph of part of area shown in Plate 2, fig. C.

Lemma lobes absent, lemma margin free at top, densely ciliate along top margin, the hairs 0.15-1.00mm.
Lemma crown hairs 3.0-3.8mm, very fine c. 0.01mm diameter, sparse, of c. 20 hairs.
Awn twice kneed, the column c. 16.0 x 0.30mm diameter above articulation and 6.0-8.0mm to first knee, densely hairy, the hairs c. 0.25mm and closely appressed to column, moderately dense on bristle angles.
Palea 4.3mm, the tip hard and reaching to the top of lemma, slightly thinner than lemma with a minute line of hairs on upper 1/3 of back.
Anthers three, of which two 0.65mm, one 0.85mm.
Lodicules three, of which two 1.6mm, one 1.2mm.

PLATE 1. - Scanning micrographs of Adaxial Leaf Surface Ornamentation within 10mm of ligule; x 80 (approx.).

Figures 1-8 Species growing in Tasmania.

FIG. 1. - *Stipa aphylla* (Rodway) Townrow, *"Townrow 246"* (HO) (matched with type specimen), blade 3 from culm base.

FIG. 2. - *S. flavescens* Labillardière, *"Labillardière*, Webb" (K. 35) (type specimen), blade 2 from culm base.

FIG. 3. - *S. mollis* R. Brown, "Oct 1932, *Cleland*" (K. 487) (matched with type specimen), blade 3 from culm base.

FIG. 4. - *S. semibarbata* R. Brown, *"Townrow 248"* (K) (matched with type specimen), blade 2 from culm base.

FIG. 5. - *S. nervosa* var. *neutralis* Vickery, *"Burbidge 2935"* (K) (matched with type specimen), blade 3 from culm base.

FIG. 6. - *S. pubinodis* Trinius and Ruprecht, *"Townrow 247"* (HO) (matched with type specimen), blade 2 from culm base.

FIG. 7. - *S. bigeniculata* Hughes, "Jan 1948, *Thomas*" (K) (matched with type specimen), blade 2 from culm base.

FIG. 8. - *S. clelandii* Summerhayes and Hubbard, "Sheet 2, *Cleland S. 40*" (K) (type specimen), blade 3 from culm base.

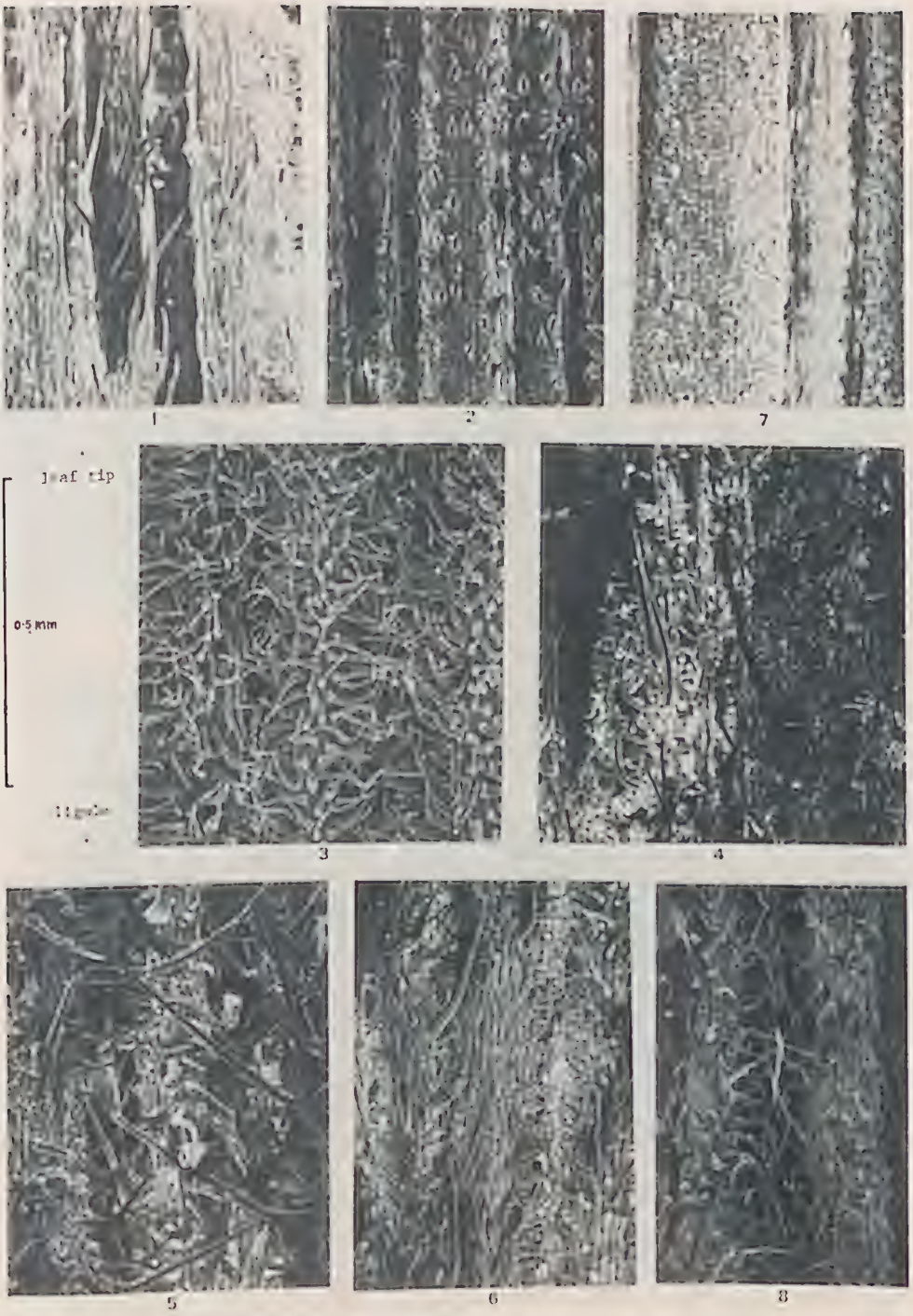


PLATE 1

PLATE 2. - Scanning micrographs of Adaxial Leaf Surface Ornamentation within 10mm of ligule; x 80 (approx.).

Figures 9-12 Species growing in Tasmania.
Figures 13-15 Species not recorded in Tasmania.

FIG. 9. - *Stipa stuposa* Hughes, "Jan 1902, *Maiden* and *Cambage*" (K) (matched with type specimen), blade 3 from culm base.

FIG. 10. - *S. stipoides* (Hooker) Veldkamp, *"Tilden 754"* (K), blade 3 from culm base.

FIG. 11. - *S. variabilis* Hughes, "left hand specimen, Sheet A, *Drummond 961"* (K) (type specimen), blade 2 from culm base.

FIG. 12. - *S. falcata* Hughes, *"Burbidge 1817"* (K) (matched with type specimen), blade 2 from culm base.

FIG. 13. - *S. nervosa* Vickery, "Dec 1953, *Vickery*" (K) (matched with type specimen), blade 3 from culm base. Compare with *S. nervosa* var. *neutralis* (Plate 1, fig. 5).

FIG. 14. - *S. pubescens* R. Brown, *"Pullen 3997"* (K) (matched with type specimen), blade 2 from culm base. Compare with *S. pubinodis* (Plate 1, fig. 6) and *S. nervosa* var. *neutralis* (Plate 1, fig. 5).

FIG. 15. - *S. blackii* Hubbard, "Nov 1934, *Butchee*" (K) (matched with type specimen), blade 2 from culm base. Compare with *S. clelandii* (Plate 1, fig. 8) and *S. stuposa* (fig. 9 above).

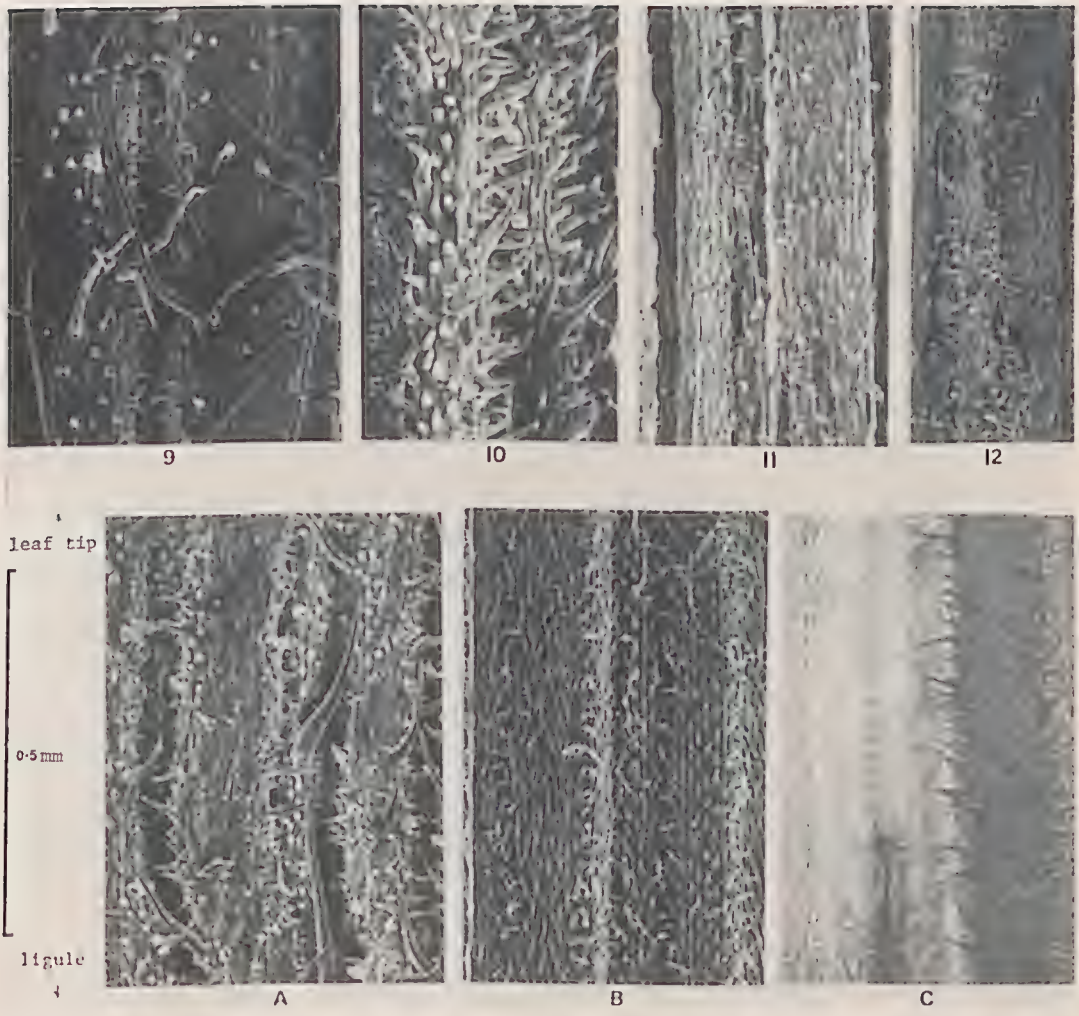


PLATE 2

Papers and Proceedings of the Royal Society of Tasmania, Volume 112, 1978.

(ms. received 5.1.1978)

OBSERVATIONS ON SOME TASMANIAN FISHES : PART XXIV

by E.O.G. Scott
Launceston

(with six tables and three text-figures)

ABSTRACT

ISURIDAE. *Isurus oxyrinchus* Rafinesque, 1810: Tasmanian example described and figured; exhibits one feature stated to be diagnostic of *I. paucus* Guitart Manday, 1966; comparison with nominal species; some aspects of body form specified (some comparison with other species).
MELANOSTOMATIADAE. *Echiostoma barbatum* Lowe, 1843: first Australian report of species; Tasmanian specimen from alimentary canal of *Hyperoglyphe porosa* (Richardson, 1845), general description; also noted, two Australian Museum examples from New South Wales and Queensland or New South Wales.
GONORHYNCHIDAE. *Gonorhynchus greyi* (Richardson, 1845): general observations; location of paired and of unpaired fins at integral nodes along anteroposterior axis of fish in a loglog plot.
ANTENNARIIDAE. *Echinophryne crassispina* McCulloch & Waite, 1918: first Tasmanian record; general observations; some aspects of body form specified : key to Tasmanian species.
CARAPIDAE. *Carapus homei* (Richardson, 1846): Tasmanian status doubtful. *Carapus rendahli* Whitley, 1941: first satisfactory Tasmanian record; specimen described : key to reported Tasmanian species.
PLESIOPIDAE. *Trachinops caudimaculatus* M'Coy, 1890: Tasmanian status doubtful. *Trachinops rodwayi* (Johnston, 1902): a local *Trachinops* described and figured; referred to Johnston's species, hitherto unrecognized since its description and hitherto treated as synonymic with M'Coy's Victorian species : key to reported Tasmanian species.
APOGONIDAE. *Gronovichthys lemprieri* (Johnston, 1883): generic status; observations on new material; scaly para-anal sheath reported; some aspects of growth and form examined.
CENTROLOPHIDAE. *Schedophilus huttoni* (Waite, 1910): first Tasmanian record (some earlier reports apparently based on (incorrect) synonymization with *Tubbia tasmanica* Whitley, 1943); general account of specimen, including aspects of body form. *Coroplopus dicologlossops* Smith, 1966, from South Africa, considered a synonym of Waite's species.
OSTRACIONTIDAE. *Lactoria diaphana* (Bloch & Schneider, 1801): second reported Tasmanian example; specimen described; some aspects of body form specified (some comparative data from undetermined Queensland species).

INTRODUCTION

This paper follows the general plan of others in the series: an exceptional feature is the inclusion, along with a Tasmanian record, of a notice of two extralimital examples of a species, *Echiostoma barbatum* Lowe, 1843, now first reported from Australia. Linear measurements are given throughout, unless otherwise specified, in millimetres, the name of the unit commonly being omitted. The symbols *Ls*, *Lt*, *TLs*, *TLt* denote standard length, total length, thousandths (permillages) of standard length, thousandths of total length, respectively. Registration numbers denoted by Q.V.M. are those of the Queen Victoria Museum and Art Gallery, Launceston. Certain other conventions are noted in earlier contributions.

Observations on some Tasmanian Fishes

Family ISURIDAE

Genus *ISURUS* Rafinesque, 1810

Isurus Rafinesque, 1810, CARATT. GEN. SPEC. SICIL., p.11. Type-species, *Isurus oxyrinchus* Rafinesque.
Oxyrhina L. Agassiz, 1835, POISS. FOSS., FEUILL. ADDIT., pp.71-86. Type-species, '*Lamna oxyrhina* Cuvier and Valenciennes MSS' = *Isurus oxyrinchus* Rafinesque.
Oxyrrhina Bonaparte, 1846, CAT. PESC. EUROP., p.17. Type-species, *Oxyrhina gomphodon* Müller & Henle = *Isurus oxyrinchus* Rafinesque.
Plectrosoma Gistel, 1848, NATURG. TIER., p.10; to replace *Oxyrhina* L. Agassiz, 1835.
Isuropsis Gill, 1862, *Ann. Lyc. Nat. Hist. N.Y.*, 1, p.397. Type-species, *Oxyrhina glaucus* Müller & Henle.

Isurus oxyrinchus Rafinesque, 1810
(fig. 1)

Isurus oxyrinchus Rafinesque, 1810, CARATT. GEN. SPEC. SICIL., p.12, pl. 13, fig. 1. Type locality: Sicily.
Isurus oxyrinchus Garman, 1913, *Mem. Mus. Comp. Zool. Harv.*, 36, p.37: Bigelow & Schroeder, 1948, *Sears Found. Mar. Res., Bull.*, 1, p.124, figs 18, 19: Smith, 1957, *Rhodes Univ. Ichth. Bull.*, 1, p.94, pl. 1, and *ibid.*, 1958, 10, p.134, fig. 2: Garrick & Schultz, 1963, *in* SHARKS AND SURVIVAL (Gilbert ed.), p.17, fig. 5: Lineaweaver & Backus, 1970, NAT. HIST. SHARKS, p.97, unnumbered figs on pp.98, 99, 103: Scott, 1974, *Tasm. Fisher. Res.*, 8(1), p.7, fig. 2b: Garrick, 1967, *Proc. U.S. Nat. Mus.*, 118, p.674, figs 6, 9, pl. 2.
Isurus oxyrhynchus [*sic*]: Thomson, 1974, FISH OCEAN AND SHORE, p.113.
Isurus spallanzanii Rafinesque, 1810, CARATT. GEN. SPEC. SICIL., pp.45, 60. Type locality: Sicily.
Oxyrhina gomphodon Müller & Henle, 1838, SYST. BESCHR. PLAGIOST., pp.68, 191, pl. 28.
Oxyrhina gomphodon: Cross, 1885, *Pap. Proc. R. Soc. Van Diemen's Land*, 3(1), p.81.
Oxyrhina glauca Müller & Henle, 1838, SYST. BESCHR. PLAGIOST., p.69, pl. 29. Type locality: 'Java' = Japan. [There is good reason to believe the original locality record is an error: following comments by Schlegel (FAUN. JAP., 1842, p.302) it is now generally accepted the type came from Japan.]
Oxyrhina dekayi Gill, 1861, *Proc. Acad. Nat. Sci. Philad.*, p.60.
Isurus glaucus: Garman, 1913, *Mem. Mus. Comp. Zool. Harv.*, 36, p.38: Ogilby, 1916, *Mem. Qld. Mus.*, 5, p.74 ('to at least 3.66 mm'!): McCulloch, 1919, *Aust. Zool.*, 1(7), p.223, pl.17, fig.22a; and 1927, FISH. FISHLIKE ANIM. N.S.W., ed. 2, p.8, pl.2, fig.22a (text cites pl.17, which is plate number inadvertently retained from McCulloch, 1919); and 1929, *Aust. Mus. Mem.*, 5(1), p.15: Waite, 1921, *Rec. S. Aust. Mus.*, 2(1), p.21, not fig. 27, which is *Lamna nasus* (Bonnaterre, 1788); and 1923, FISH. S. AUST., p.39, not unnumbered fig. on p.39, which is *Lamna nasus* (Bonnaterre, 1788): Lord & Scott, 1924, SYNOP. VERT. ANIM. TASM., pp.6, 23, unnumbered fig. on p.23: McCulloch & Whitley, 1925, *Mem. Qld. Mus.*, 8(2), p.129: Phillipps, 1926, *Trans. Proc. N.Z. Inst.*, 56, p.530, pl.87 (type specimen of *Isurus mako* Whitley, 1929); and 1927, *N.Z. Mar. Dept. Fisher. Bull.*, 1, p.8: Whitley, 1929 (*ex* Johnston ms), *Pap. Proc. R. Soc. Tasm.*, (1928), p.45: Moorhouse, 1938, *S. Aust. Nat.*, 19(2), p.245, not fig. 21, which is *Lamna nasus* (Bonnaterre, 1788): Roedel & Ripley, 1950, *Calif. Fish Game, Fish Bull.*, 75, p.44, fig.28: Munro, 1956, HANDBK AUST. FISH. *in Fisher. Newsl.* (now *Aust. Fisher.*) 15(7), p.3, fig. 13 (of HANDBK): Garrick & Schultz, 1963, *in* SHARKS AND SURVIVAL (Gilbert ed.), p.17, fig.6: Stead, 1963, SHARKS RAYS AUST. SEAS, pp.33, 199, fig.16: Marshall, 1964, FISH. GREAT BARRIER REEF AND COASTAL WAT. QLD , p.25, not pl.10, fig. 33, which is *Lamna nasus* (Bonnaterre, 1788); and 1966, TROP. FISH. GREAT BARRIER REEF, p.165, not pl.10, fig.33, which is *Lamna nasus* (Bonnaterre, 1788): Scott, Glover & Southcott, 1974, MAR. FRESHW. FISH. S. AUST., p.32, unnumbered fig. on p.32.

Isurus glacus [*sic*]: Lord, 1923, *Pap. Proc. R. Soc. Tasm.* (1922), p.62; and 1927, *J. Pan-Pac. Res. Inst.*, 2(4), p.12.
Isurus mako Whitley, 1929, *Rec. Aust. Mus.*, 17(3), p.101. Type locality: New Zealand. (Based on *Isurus glaucus*: Phillipps, 1926, *Trans. Proc. N.Z. Inst.*, 56, p. 530, pl. 87).
Isurus mako: Phillipps, 1932, *N.Z. J. Sci. Tech.*, 13, p.227. Type locality: South Africa.
Isurus bideni: Whitley, 1940, FISH. AUST., 1, p.124: Barnard, 1949, *Ann. S. Afr. Mus.*, 36, p.342.
Isurus cepedii: Fowler, 1945, *Monogr. Acad. nat. Sci., Philad.*, 7, p.43, figs 3,4.
Isurus tigris: Smith, 1957, *Rhodes Univ. Ichth. Bull.*, 6, pp. 91, 92, 93, 96, pl.1, text fig. 1.
Isurus tigris tigris Smith, 1957, *Rhodes Univ. Ichth. Bull.*, 6, p.96 (habitat, Atlantic).
Isurus tigris africanus Smith, 1957, *Rhodes Univ. Ichth. Bull.*, 6, p.96, pl. 1 (legend, *Isurus tigris* Atwood [= (Atwood)]). Type locality: Algoa Bay (habitat, South Africa).
Isurus tigris mako Smith, 1957, *Rhodes Univ. Ichth. Bull.*, 6, p.96 (habitat, Australasia).
Isurus africanus Smith, 1958, *Rhodes Univ. Ichth. Bull.*, 10, p.134. Type locality : Algoa Bay.
Isuropsis glaucus: Gill, 1864, *Ann. N.Y. Lyc.*, 7, p.398.
Isuropsis dekayi: Gill, 1864, *Ann. N.Y. Lyc.*, 7, p.409.
Isuropsis glauca: Zeitz, 1908, *Trans. R. Soc. S. Aust.*, 32, p.321.
Isuropsis sp. Whitley, n.d. (1958?) AUST. ENCY., 8, 82.
Isuropsis mako: Whitley, 1934, *Mem. Qld Mus.*, 10(4), p.194; and 1940, FISH. AUST., 1, p.122, figs 129, 131, not fig. 130, which is *Lamna nasus* (Bonnaterre, 1788); and n.d. (1958?) AUST. ENCY., 5, p.467, not unnumbered fig., which is *Lamna nasus* (Bonnaterre, 1788); and, 1963, *in* SHARKS AND SURVIVAL (Gilbert ed.), p. 337, fig. 2(6); and 1964, *Proc. Linn. Soc. N.S.W.*, 89(1), p.33: Phillipps, 1946, *Domin. Mus. Rec., Zool.*, 1(2), p.8, fig.2: Scott, 1962, MAR. FRESH WAT. FISH. S. AUST., p.28, not unnumbered fig., which is *Lamna nasus* (Bonnaterre, 1788): Coppleson, 1962, SHARK ATTACK, 2nd ed., p.22, fig. 6 on p.22: Goadby, 1968, SHARKS OTHER PRED. FISH AUST., p.20, unnumbered figs on pp. 21, 59.
Isuropsis oxyrinchus: Whitley, 1968, *Aust. Zool.*, 15(1), p.8.
Lamna oxyrhina: L. Agassiz, 1838, POISS. FOSS., 3, p.86.
Lamna punctata Storer, 1839, REPT. FISH., p.185, pl.3, fig.2. Type locality : Bermuda. Not *Lamna punctata* De Kay, 1842, *ZOOL. N.Y., FISH.*, p.352, pl.63, fig.206 (New York) = *Isurus paucus* Guitart Manday, 1966, *Poeyana* (ser. A), 15, p.1, 3 figs, *nom. nov.* for De Kay's species (Cuban waters).
Lamna latro Owen, 1853, CAT. OSTEOL. ROY. COLL. SURGEONS, 1, p.96.
Lamna glauca: Günther, 1870, CAT. FISH. BRIT. MUS., 8, p.391: Ramsay, 1881, *Proc. Linn. Soc. N.S.W.*, 5(1), p.96: Macleay, 1882, *Proc. Linn. Soc. N.S.W.*, 6(2), p.357.
Lamna spalanzanii: Günther, 1870, CAT. FISH. BRIT. MUS., 8, p.380: Day, 1878, FISH. INDIA, 4, p.722, pl.186, fig.2: Phillipps, 1926, *Trans. Proc. N.Z. Inst.*, 56, p.530.
? Lamna cornubica: Johnston, 1883, *Pap. Proc. R. Soc. Tasm.* (1882), p.138; and 1891, *ibid*, p.17 (p.38 of reprint). Probably not *Squalus cornubicus* Gmelin, 1789 = *Squalus nasus* Bonnaterre, 1788 = *Lamna nasus* (Bonnaterre, 1788) : *cf.* Lord & Scott, 1924, p.23.
Lamna guntheri Murray, 1884, *Ann. Mag. Nat. Hist.*, ser. 5, 13, p.349. Type locality: India.
Lamna huidobrii Philippi, 1887, *Ann. Univ. Chile*, 71.
Lamna guntheri: Day, 1888, FISH. INDIA, SUPPL., p.810: Smith, 1957, *Rhodes Univ. Ichth. Bull.*, 6, p.94.
Lamia nasus Lahille, 1928, *Ann. Mus. Nac. B. Aires*, 34, p.310.
Squalus cepedii Lesson: 1830, VOY. 'COQUILLE', ZOOL., 2, p.93. Type locality: Equatorial Atlantic.

Carcharias tigris Atwood, 1869, *Proc. Bost. Soc. nat. Hist.*, 12, p.268. Type locality: Gulf of Mexico.

Synonymy. No attempt has been made in the above table of synonymy to cope with the very extensive overseas literature, the material collated having the two limited aims, first, of presenting a tolerably representative selection of Australian sources, secondly, of enumerating (usually with citation of only a primary reference) the more important names that have at various times been given to this shark.

The several times repeated notation, 'not fig., which is *Lamna nasus* (Bonnaterre, 1788)' is occasioned by the reproduction in a number of Australian texts of a figure originally presented by Waite (1921, fig.27), the shark this depicts evidently being referable not to *Isurus* but to *Lamna*, as these genera are conventionally understood, since, as pointed out by Smith (1957, p.91) the dorsal origin is anterior to the hind pectoral angle, and, moreover, a secondary caudal keel, the presence of which is characteristic of the latter genus, is clearly visible in the original illustration — not always readily discernible in reproductions (Smith notes that in publishing a version of this figure as an illustration of *Isurus glaucus* Barnard (1927, pl. 1, fig. 6) deleted the extra keel).

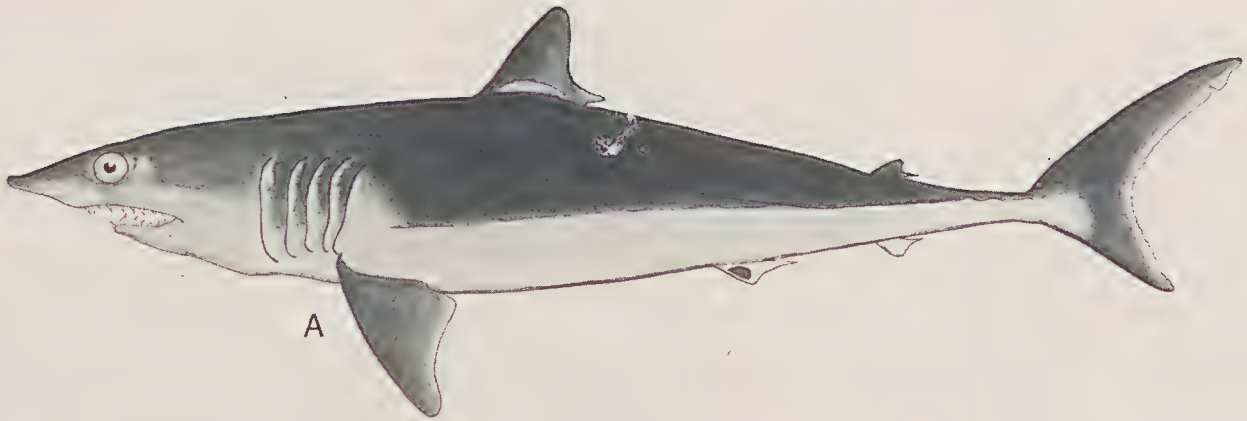
Material. A male, length to origin of upper caudal lobe 698, total length 857, caught east of Cape Barren Island, Bass Strait, 16 February 1977, by Mr B. Bensemann, Q.V.M. Reg. No. 1977/5/11.

Detailed and accurate descriptions of *Isurus* species are rare (Smith, 1957, p.51) and reliable depictions are markedly less numerous in scientific works than as photographs in angling publications (on which latter some rather unsatisfactory systematic conclusions have been based). No comprehensive series of dimensions such as the 'set of standard measurements for comparative and biometric studies of Australian sharks' devised by Whitley (1943b) is available for any Australian isurid, and morphometric data for examples of *Isurus* from our waters are virtually confined to some measurements and proportions recorded in two papers by Whitley (1931, 1934a). A welcome addition to knowledge of *Isurus* in the Australasian region is the recent comprehensive review of the genus by Garrick (1967). A detailed description of the present specimen follows; further, opportunity has been taken to examine some aspects of general form, particularly those features exhibiting metrically specifiable patterns. Though identifiable as *I. oxyrinchus* Rafinesque, 1810, the specimen possesses one feature stated to be characteristic of *I. paucus* Guitart Manday, 1966.

Dimensions. A standard schedule of measurements of sharks has been proposed by Whitley (1943b, pp.114-115). Data for the present specimen in accordance with this scheme are set out in the next three paragraphs, all dimensions being in millimetres.

Head measurements:- H1-H8. Length of head to first gill slit 190. Length of head to last gill slit 230. Tip of snout to anterior margin of eye 65. Breadth of snout immediately before eyes 52. Snout [tip] to origin of pectorals 215. Snout [tip] to origin of ventrals 487. Eye, horizontal diameter 19. Eye, vertical diameter (outside nictitating membrane, where present) 20. Interorbital 59. Eye to spiracle [spiracle not detected]. Length of nostril [anteroposterior] 3.5 [oblique] 9. Internarial, between posterior angles 36. Preoral length 58. Width of mouth (distance between angles) 70. [H15, H16 upper, lower labial fold — no distinct folds present; a shallow groove, 8 long, running backward and slightly outward from angle of mouth]. Height of first gill opening 72.5. Height of last gill opening 67.

Body measurements:- B1-B9. Length, snout [tip] to upper caudal pit 698. Length, snout [tip] to vent (middle) 507. Predorsal length 327. Depth at origin of first dorsal 138. Breadth below origin of first dorsal 120. Depth of caudal



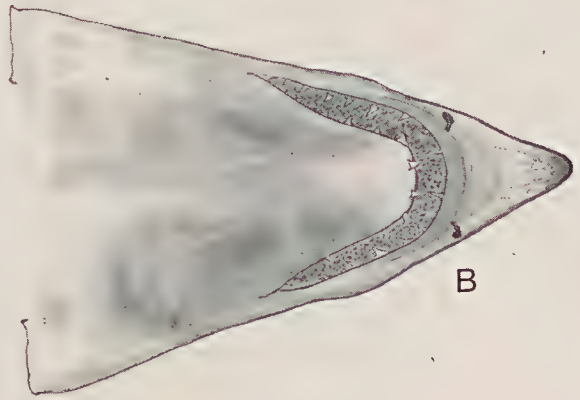


FIG. 1. - *Isurus oxyrinchus* Rafinesque, 1810. Male, length to origin of upper caudal lobe 698 mm, total length 857 mm, caught east of Cape Barren Island, Bass Strait, 16 February 1977, by Mr B. Bensemann; Queen Victoria Museum Reg. No. 1977/5/11. A lateral aspect, x ¼ approx. B, ventral surface of head, showing exceptional pigmentation, x ½.

peduncle (immediately before pit) 49. Breadth of caudal peduncle (immediately before pit) 23. Claspers, outer margin 24. Claspers, inner margin to membrane at base 28.

Fins:- F1-F22, omitting F13 (sketch: see fig. 1). First dorsal, anterior margin 93. First dorsal, base 75. First dorsal, last ray 15. Interdorsal 212. Second dorsal, anterior margin 21. Second dorsal, base 11. Second dorsal, last ray 16.5. Second dorsal to caudal pit 71. Anal fin, anterior margin 23. Anal fin, base 14. Anal fin, last ray 20. Anal base to caudal pit 71. Pectoral, length 144. Pectoral base [anteroposterior] 42, [oblique] 45. Origin of pectoral to that of ventral 260. Ventral fin, length of anterior margin [right fin] 39, [left fin] 42. Ventral fin, base (to outer angle of clasper) 41. Ventral fin, length of last ray, measured externally (superiorly) 20. Ventral fin to anal origin 137. Caudal, from pit, upper lobe 180. Caudal, from pit, lower lobe 110.

Additional measurements:- In a later paper Whitley (1945) found it expedient to supplement his schedule in a description of an example of *Mapolamia spallanzani* Le Sueur, 1822 by a dozen additional entries as follows. Total length 857 (see remarks below, under "Proportions", on problem presented by posture of caudal in preserved specimen). Distances between gill openings, measured anteroposteriorly between free margin of fold at middle 17.0, 11.0, 10.0, 6.4, measured directly with dividers between lower ends of clefts 14.8, 11.6, 10.5, 7.4. Eye to first gill opening 116. Snout [tip] to level of angle of mouth 121. Ramal length [direct] 94. Tip of snout to outer angle of nostril [direct] 47. Inner angle of nostril to mouth [direct] 23. Interval between pectoral and first dorsal origins 100; between first dorsal and ventral origins 160. Depth above ventral origin 96, termination [tip of fin] 72.

Some other dimensions recorded by other authors may be noted. Pectoral, distal margin (here, and in fins below, direct, as chord) 112, inner margin (chord) 38; length to end of adpressed fin 365. Interpectoral, anterior 101, posterior 65. First dorsal, distal margin 76, vertical height 70; second dorsal 15, 11; anal 15, 12. Caudal, posterior border (chord) 197; length (chord) from most anterior point on posterior border to origin of lower lobe 70, to tip of lower lobe 82, to tip of upper lobe 134. Width of caudal peduncle at caudal pit (without keel) 44. Measurements of girth at 10 equal intervals between snout tip and first gill slit are considered separately below (section, "Girth of head"). Girth at pectoral origin (virtually level of first gill slit) 383, first dorsal origin 427, first dorsal termination (end of base) 406, ventral origin 302, ventral termination (end of base) 266, end of adpressed fin 254, second dorsal origin 196, anal termination (end of fin) 167, origin of caudal (upper lobe) 100.

Proportions. The subjoined series of proportions covers all those reported by Phillipps (1926, p.530) for the New Zealand shark later nominated as the holotype of *Isurus mako* Whitley, 1929; Phillipps' variates being cited in parentheses. In recording proportions one term of which is to denote overall size of specimen Phillipps, following a general practice, takes as that term total length. In a general paper on *Isurus* Smith (1957, p.93) recommended the adoption of length to origin of upper caudal lobe. This convention has two advantages. First, of course, it takes cognizance of the less than basic nature of an appendage as a constituent element of total length, becoming closely comparable with the formal 'standard length' of teleost systematics (the measurement being here so named; symbol *Ls*); secondly, it has special practical relevance in cases such as the present where in a preserved specimen the normal posture in life of the caudal is difficult of precise determination — thus in our example it has been found that manipulation of the angles of the axes of the caudal lobes, effected without resulting in any obvious distortion, gives a total length ranging from 835 to 891 (adopted value 857). Accordingly, to permit direct comparison with data in either system both *Lt* and *Ls* values are here recorded,

the latter in square brackets.

Head to first gill slit 4.51 [3.67], to last gill slit 3.73 [3.03] in *Lt* [*Ls*], (head ¼ length). Depth at pectoral origin 7.08 [5.77] (7.61), at first dorsal origin 6.21 [5.06] (under first dorsal 6.19) in *Lt* [*Ls*]. Snout in head to first gill slit 2.92, to last gill slit 3.54 (3 in head). Length to origin of first dorsal 2.62 [2.13] (2.47), to origin of pectoral 3.78 [3.07] (4.13) in *Lt* [*Ls*]. Length to first gill slit 1.39 times (equal to) interval between ventral and anal origins; or 3.28 (five times) preoral length. Pectoral in head to first gill slit 1.32, to second gill slit 1.60 (in head 1.3); its base 1.55 (1.38) in snout. Height of first dorsal 2.71 in length to first gill slit, 3.29 in length to last (about 2 in head). Secondary lobe of upper caudal lobe 6.92 in ('5.3 times' = 5.3 in) upper caudal lobe. Lower caudal lobe 1.64 in upper caudal lobe (1.27; also 'upper caudal lobe more than ¼ [= 1¼] lower caudal lobe'): on p.531 Phillipps observed Muller & Henle [1838] showed the relation of the lower to the upper lobe of caudal [i.e., times former is contained in latter] to be 1.44. In Waite's figure [1921, fig. 27] it is 1.36 and in the New Zealand examples [? example] 1.27 - note, however Waite's figure is not, as labelled, *Isurus glaucus*, but *Lamna nasus* (Bonnaterre, 1788).

As pointed out by Smith (1957, p.96), Phillipps' illustration (pl.87) and his text are not always in agreement. Thus text has 'snout (i.e.,tip of snout) to first gill opening equals distance from origin of ventral to origin of anal, or five times pre-oral length'; approximate values derivable from plate 1.3, 2.8 [our specimen 1.39, 3.28]; head 4 in total length (4.24) [3.73]: height of first dorsal 'about 2' (2.2) [3.3] in head; depth at pectoral origin 7.61 (7.1) [7.08], below first dorsal 6.19 (about 4) [6.21] in *Lt*. The disposition of the gill slits as figured differs markedly from that in our specimen (slits subparallel, *cf.* diverging noticeably above; line joining lower ends subhorizontal, *cf.* sloping upward and forward: see section on gill slits, below); the depiction is probably incorrect. Indeed, 'there are few reliable illustrations of [*I*] *glaucus* other than photographs of anglers' catches' (Smith, p.94). Furthermore, continued confusion has occurred in Australia in the figuring of the present species, the illustration in Waite's South Australian catalogues (1921, fig.27; 1923, fig.27) as *Isurus glaucus* —reproduced, for example, as *Isuropsis mako* by Whitley (1940, fig. 130); and, extralimitally, with some modification, as *I. glaucus* by Barnard (1927, pl. 1, fig. 6) ——being, as noted by Smith, a representation of *Lamna nasus* (Bonnaterre, 1788), the characteristic secondary keel being clearly evident in the original figure.

Some additional proportions of diagnostic value may be noted. Eye 10.0 in length to first gill slit, 12.1 in length to fifth gill slit, 3.42 in snout, 3.11 in interorbital. Base of first dorsal 4.36 in length to fin, 1.07 vertical height of fin, 6.82 base of second dorsal, 5.36 base of anal, 1.79 base of pectoral, 2.03 base of ventral. Length to origin of second dorsal 1.40 (1.14), of anal 1.37 [1.12], of ventral 1.76 (1.43) in *Lt* [*Ls*]. Intervals between fin origins : pectoral-first dorsal 8.57 [6.98]; pectoral-ventral 3.30 [2.68], first dorsal-ventral 5.36 [4.36], ventral-anal 6.26 [5.09], second dorsal-caudal at upper pit 10.2 [8.31], anal-caudal at lower pit 10.1 [8.21] in *Lt* [*Ls*]. Girth at first gill slit 2.35 [1.98], pectoral origin 2.27 [1.85], first dorsal origin 2.06 [1.67], end of first dorsal base 2.12 [1.72], ventral origin 2.13 [1.74], end of ventral base 5.19 [4.23], second dorsal origin 4.20 [3.42], end of anal base 5.19 [4.23], lower caudal pit 8.40 [6.84] in *Lt* [*Ls*].

Location of certain morphological landmarks. It has been reported in Part XXIII (1977) that it has been found, for a number of sharks, that when the logarithms of the lengths from snout tip to certain notable morphological points are plotted against the logarithms of certain natural numbers within the range 1-10, the resultant graph is significantly linear; and data for two examples of *Sphyrna zygaena* (Linné, 1758) are there recorded, one affording the first Australian report of the species (Scott, 1973).

With L = length, mm, from tip of snout to one of the following seven-member set {back of mouth, pectoral origin, first dorsal origin, ventral origin, anal origin, caudal origin (taken as upper caudal pit), total length} and with N = relevant natural number of the set {1,2,3,5,6,7,9}, the equation for the best straight line (sum of logarithmic, not arithmetic, deviations minimized) for the present specimen is $\log L = 0.8961 \log N + 2.0837$. Measured (in parentheses predicted) values of L at the seven points are 121 (121), 227 (226), 327 (325), 487 (513), 624 (604), 709 (693), 857 (867). As for similar graphs for other species, the fit is very satisfactory, with $t = 56.932$*** (*cf.* for the two specimens of the hammerhead 54.523***, 40.105***, d.f. 5).

As noted in Part XXIII (1977, p.122), in these length-number formulations the same morphological site may fall at different integers in different species, the general slope of the graph being largely determined by the location of the first member of the series, length to back of mouth, which is variously positioned in different families on log 1, log 2, or log 3. Whereas in the present specimen the integral abscissal values for the seven length-to measurements are 1,2,3,5,6,7,9, the corresponding numbers for the same set of dimensions in the two examples of *Sphyrna zygaena* were 2,3,4,6,7,8,10. The variable locus of the first datum serves of course as an index of preoral length relative to general length of head, a feature exhibiting notable intrafamilial stability. There is some evidence to suggest that the location of total length on log 9, instead of on log 10, may be associated with possession of a short caudal fin: it may perhaps be speculated that in such cases the log 10 point may be morphologically (and hydrodynamically?) significant, representing the opisthion of Gregory (1928) or some similar space-datum. The *opisthion* is the point of intersection of the anteroposterior axis (*horizontal*), drawn from most anterior point of fish (*prosthion*) through midpoint of caudal peduncle (*pygidion*) and a line drawn from summit of dorsal profile (*apex*) through lowest point on dorsal border of caudal peduncle (*epipygidion*). It would seem possible this point may bear a significant relation to the boundary of the slipstream.

Two implications for taxonomy naturally suggest themselves. First, the character of the pattern as manifest in its particular combination of the members of the length and number sets would appear to be characteristic for taxa higher than species. Secondly, with the primary data standardized for overall length of individual (with which slope of graph shows positive correlation) it might well be the parameters of the equation would prove diagnostic at species level.

Fin borders. The measurements of fin borders recorded elsewhere in this paper represent, in accordance with common practice, the chord of the curve. (The chord of the anterior border is commonly taken as the length of the fin (in caudal, of relevant lobe, that of upper specifying length of fin), and no other convention is widely followed, at least for pectoral, first dorsal caudal; the usage, however, is not invariable, Garrick & Schultz (1963, fig. 1a), for example, defining length of second dorsal as distance, between parallels, from front of base to free hind tip). Examination of length following the curve shows that in the present specimen the fins fall into two well-defined categories. In the first group, comprising first and second dorsals and anal, two borders (not necessarily the same pair) are equal or subequal in length; the anterior, posterior (distal) and inner borders in these three fins being 91, 88, 38 mm; 19, 17, 19; 21, 17, 17. In the second group the three borders plotted (in different sequence) on logs 1,2,3 yield on approximately linear graph. For pectoral, with anterior, posterior, inner borders 152, 118, 41, the regression equation is $L = 235.14 \log N + 42.68$; $t = 14.403$*, predicted values being 155, 113, 43 : caudal, lower, upper, posterior borders 128, 187, 223; $L = 198.78 \log N + 127.74$; $t = 94.990$**; predicted 128, 188, 223: pelvic, inner, posterior, anterior borders 16, 32, 47; $L = 63.71 \log N + 14.90$; $t = 7.600$ (significant only at P 0.1); predicted 15, 34, 46. It would certainly be of interest to extend the investigation to other species: some preliminary trials suggest that of the logarithmic formulations here noted in the mako for pectoral, pelvic, caudal, those for the paired fins (but probably not that for the

caudal) are applicable to a number of other species.

Head in plan. The snout, regularly characterized in texts as pointed (*cf.* also the synonymic generic name *Oxyrhina*, the specific name *oxyrinchus*, and the vernacular name sharp-nosed mackerel shark) is indeed markedly so, its widths at its anterior one-third, middle, posterior two-thirds being 0.37, 0.60, 0.85 width at front of eyes, the corresponding relative depth values being 0.58, 0.68, 0.81. Its outline in plan continues forward much the same general sense of the outline of the rest of the head in advance of first gill slit.

In a study in Part XXIII (1977) of the head of a specimen of *Carcharhinus greyi greyi* (Owen, 1853) it was pointed out that while conventional specifications of the snout as 'long and pointed', 'bluntly rounded', 'moderately rounded', 'more broadly rounded than in preceding species' — these examples being successive entries in the Handbook (Munro, 1956a) - clearly have some value, equally clearly their significance would be enhanced by some degree of quantification; and this desideratum was provided for that specimen in the form of several polynomial equations. A tracing has been made of the outline of the head of the present specimen forward from first gill slit (here selected as origin in view of the existence of several local irregularities in outline - at least partly adventitious — in the interval between first and last gill slits), the anteroposterior axis has been stepped off in tenths, and widths at these intervals measured. With W = width, mm, and N = serial number of decile, counting caudad, $W = 8.95 + 20.151\ N - 0.7008\ N^2$ Measured widths (in parentheses estimated) are 28 (28.4), 47.5 (46.4), 62.5 (63.1), 78.0 (78.3), 91.5 (92.2), 107.0 (104.0), 114.5 (115.7), 124.0 (125.3), 135.0 (133.0), 140.0 (140.4). It will be seen the fit is a very satisfactory one; $R = 0.9980$.

To introduce a measure of generalization, making possible both intraspecific and interspecific comparison of individuals of differing overall size, the head widths, given above as absolute dimensions (mm), may be expressed in terms of some convenient morphometric unit. With widths as permillages of maximum width the equation is $W = 63.62 + 144.022\ N - 5.01114\ N^2$. As the head of the whaler shark mentioned above was severed slightly in advance of level of first gill slit, the use of length to the gill slit thus being ruled cut, decile widths were calculated as percentages of width at front of mouth, the second degree equation being $W = 35.14 + 16.317\ N - 0.66295\ N^2$: the comparable equation here is $W = 14.36 + 31.896\ N - 1.1042\ N^2$. The coefficient of N^2 affords a measure of the pointedness of the curve, the markedly more acute form in the present specimen being evidenced by a value about one and two-thirds that for the carcharhinid.

For comparison with data that may in the future be obtained for other sharks for which length to first gill slit is available, the polynomial for this specimen, with widths as permillages of length to first gill slit is here noted, $W = 40.63 + 106.29\ N - 3.7045\ N^2$.

Some interesting comparative results are derivable from figures of the head in some standard texts, decile widths being measured along length to first gill slit, expressed as permillages of that length, and polynomials calculated. *(a). Isurus oxyrinchus* (Bigelow & Schroeder 1948, fig. 18, young male 1 690 mm long) $W = 82.77 + 70.732\ N - 3.1894\ N^2$; $W = 58.41 + 100.339\ N - 7.9242\ N^2 + 0.28393\ N^3$; successive values of F 213.70, 7.00, 5.99, of R 0.9818, 0.9845, 0.9921; percentage deviations of predicted from given values 0.0-3.9 $\bar{x}$ 1.8, 0.3-3.4, $\bar{x}$ 1.6. *(b). I. paucus* (Guitart Manday 1966, fig. 1B; length of head here measured to somewhat indeterminate end of figure, about at level of first slit) $W = 108.12 + 116.620\ N - 5.9280\ N^2$; $W = 91.63 + 131.242\ N - 9.098\ N^2 + 0.19214\ N^3$; F 92.75, 7.0, 6.0; R 0.9595, 0.9994, 0.9997; percentage deviations 0.0-3.4, $\bar{x}$ 1.18, 0.0-2.8, $\bar{x}$ 0.8. *(c). I alatus (= I paucus)* (Garrick 1966, fig. 7b) $W = 88.98 + 110.04\ N - 6.0492\ N^2$; $W = 29.30 + 162.97\ N -$

17.557 N^2 + 0.69560 N^3; W = 70.74 + 109.85 N — 1.883 N^2 — 1.9607 N^3 + 0.120842 N^4; F 58.64, 68.54, 18.73, 5.03, R 0.9381, 0.9944, 0.9986, 0.9998; percentage deviations 0.8-9.0, $\bar{x}$ = 3.1, 0.9-3.0, $\bar{x}$ 1.3, 0.2-3.8, x = 1.2. Garrick's figure shows the local sinuosity found just in advance of the gills, a feature not evident in Guitart Manday's even curve, and a decrease in mean percentage deviation is here gained in passing beyond the third to the fourth degree equation (though the F value fails to reach formal significance at the 5% level).

For pragmatic taxonomic purposes a formulation leading to a straight line graph is in some respects more convenient than a polynomial, affording a more immediate visual estimate of parameters: the chief disadvantage of the procedure here adopted is that the graph presents two segments. Plotting the ten widths, proceeding caudad, on the integral numbers 1-10 along a logarithmic abscissa is found to yield one significantly straight line, A, covering logs 1-3 and a second, B, covering logs 4-10. With widths as permillages of length to first gill slit the regression equations are: A = {1-3}, W = 3.77215 log N + 144.16; t = 13.427*; percentage deviations of estimated from observed values 3.2, 3.1, $\bar{x}$ 1.5: B = {4.10}, W = 8.33.015 log N — 93.76; t = 36.892***; percentage deviations 0.7-1.6, $\bar{x}$ 1.0. For Bigelow & Schroeder's outline of the head of their specimen of *Isurus oxyrinchus* the corresponding data are: A = {1-4}, W = 341.112 log N + 141.72; t = 7.936; percentage deviations 2.9-13.9, $\bar{x}$ 8.9: B = (5-10), W = 548.752 log N + 8.693; t = 62.516***; percentage deviations 0.2-0.7, $\bar{x}$ = 0.3 (the much greater deviations in A are attributable to the presence in the set of one aberrant variate). A two-segment line was found also for the example of *Carcharhinus greyi greyi* reported in Part XXIII (1977, p.115), with A = {1-6}, B = {7-9}. However, the approximate measurements derived from the figure of *Isurus paucus*, with obscure posterior boundary, involve three segments {1-2}, {3-8}, {9-10}.

Girth of head. The girth of the head has been measured at 10 equal intervals between tip of snout and level of first gill slit. It is found that for each of the decile sets {1-6} {7-10} — deciles numbered caudad — the relation between girth, G, and decile number, N, is, to a significant approximation, of the form $G = bN^k$. With the relation rectified the best straight line for {1-6} is log G = 0.6845 log N + 1.9343; t = 21.646***; for {7-10} log G = 0.3878 log N + 2.1770; t = 10.050**. The 10 girths, mm, (with predicted values in parentheses) are 86 (86), 138 (138), 182 (182), 220 (222), 259 (259), 296 (293); 318 (319), 338 (337), 356 (352), 364 (367). In our example of *Carcharhinus greyi greyi* a single straight line was obtained for the complete decile set {1-10}.

Mouth. The anterior border of the crescentic mouth lies behind tip of snout by 0.92 of the mouth's anteroposterior extension, the latter being 0.90 chord at the angles, or 3.2 direct distance from mouth to nostril. The upper lip is of a somewhat unusual character, taking the form of a free stiffish lamelliform fold, directed backwards and slightly downwards for a maximum (mesial) distance of 11 mm, covering much of the length of the anterior teeth, but decreasing regularly in extent backwards. Its free border is here taken as throughout defining the mouth curve. Externally it is indistinguishable in texture and color from the adjoining chin region, from which it is rather obscurely delimited by a groove, best developed in its anterior half. Overall it is quite unlike the usual flattish, moderately tumid or bluntly ridged shark upper lip. Some idea of its general character may be gathered from a photograph in Goadby (1959, unnumbered fig., p.59) of the open mouth of a mako caught at Tweed Heads, New South Wales, after taking snapper *(Chrysophrys* sp.*)* from hand lines. (A structure of comparable extent, but having more the character of a subrectangular flap, constitutes the posterior border of the mouth in the holocephalan *Callorhynchus milii* Bory de St Vincent, 1823: it completely hides the lower teeth).

The mouth curve has been examined by the methods employed in the analysis of the curve of the head in plan, and orthogonal polynomials have been calculated. For the

upper lip the third degree equation is $W = 19.72 + 8.189\ N - 0.8975\ N^2 + 0.058180\ N^3$; $R = 0.99916$. Measured values, which it was not practical to read to better than the nearest half-millimetre, are here followed in parentheses by estimated values given to the nearest one-tenth millimetre: 27 (27.1), 33.5 (33.0), 37.5 (37.8), 42 (41.8), 45 (45.5), 48.5 (49.1), 54 (53.0), 57 (57.6), 63.5 (63.1), 70 (70.0). The equation in N^4 is $W = 21.04 + 6.487\ N - 0.27507\ N^2 - 0.26868\ N^3 + 0.0038658\ N^4$.

Generalized for comparative purposes, with widths not absolute measurements as before but permillages of length to first gill slit, the third degree equation becomes $W = 105.90 + 41.502\ N - 4.4481\ N^2 + 0.2925\ N^3$ (giving calculated terminal values of 141.3, 368.6; observed 142, 368); while with widths taken as permillages of full width of mouth the equation is $W = 287.73 + 113.346\ N - 12.2852\ N^2 + 0.80906\ N^3$ (terminal values as calculated 389.6, 1011.7; actual 386, 1000). The second equation has been calculated to permit of comparison with a similar equation for *Carcharhinus greyi greyi*, namely, $W = 157.68 + 159.732\ N - 10.9677\ N^2 + 0.34217\ N^3$ (terminal values as calculated 306.8, 1000.4; actual 305, 1000). In Part XXIII the equation recorded for the whaler shark is for decile widths as percentages (not, as above, permillages) of width of mouth.

Except for a slight and brief widening shortly in advance of angle of mouth the lower jaw narrows regularly towards its rounded tip. For almost its entire length it fails to coincide with the upper jaw, lying wholly within it, having the appearance of being a stout dark-colored tongue. The third and fourth degree polynomials specifying its outline are $W = 26.80 + 9.623\ N - 0.9554\ N^2 + 0.03506\ N^3$ and $W = 21.87 + 14.656\ N - 2.7970\ N^2 + 0.28671\ N^3 - 0.011439\ N^4$. Measured values (calculated in parentheses, third degree first) are 35 (35.5, 34.1), 43 (42.5, 42.1), 49 (48.0, 47.5), 51.5 (52.4, 51.2), 55 (55.4, 53.9), 57.5 (57.7, 56.2), 59.5 (58.4, 58.3), 60.5 (60.6, 60.1), 62.5 (61.6, 61.2), 62 (62.6, 61.6). In all equations recorded so far decile numbers have been counted caudad (measurements thus increasing in magnitude from first to last). It is of interest to note that with the slightly different fit (actual equations, of course, with markedly different parameters) obtained when the calculation is made with the measurements for the lower jaw taken in reverse sequence the fourth degree equation picks up the slight increase in the second measurement shotly in advance of angle of mouth. This equation is $W = 58.69 + 4.839\ N - 1.9651\ N^2 + 0.25093\ N^3 - 0.12634\ N^4$, giving values of W as follows 61.8, 62.3, 61.3, 59.4, 57.2, 53.8, 52.0, 48.4, 43.1, 35.2.

Comparison of head and mouth curves. It may reasonably be predicated that a definable relation of some form subsists between the curvature of the head as a whole and that of the mouth cleft. An interesting ad hoc comparison of the two curves is obtained by plotting successive cumulated deciles of mouth width on successive cumulated deciles of head width, the resultant plot proving to be a straight line with one point of inflexion. For deciles {1-3}, numbered caudad, the regression equation is $\text{cum } M = 0.6431\ \text{cum } H + 10.06$; $t = 21.657$*: for deciles {4-10} $\text{cum } M = 0.4712\ \text{cum } H + 38.44$; $t = 179.994$***; measured (in parentheses estimated) values 27 (28.1), 60.5 (58.6), 98 (98.8), 140 (140.3), 185 (183.3), 233.5(233.7), 287.5 (287.7), 344.5 (346.1), 408 (409.7), 478 (475.7).

A comparison of the graph for this species with that for *Carcharhinus greyi greyi* noted in Part XXIII reveals one notable point of agreement, both plots having the point of inflexion located between the third and fourth deciles (here at 17.8% of total abcissal length, in the whaler shark at 21.5%); however, whereas here the earlier segment has the greater slope, in the other species it has the lesser slope.

Gill slits. As in other isurids the gill slits in this species are large, being visible both when the shark is viewed from above and when it is viewed from below; the largest slit here occupies 0.40 of the semigirth at its level.

In the present specimen the lengths decrease from 1st to 4th, 5th being equal to

2nd. However, Phillipps reports of the holotype of *Isurus mako* Whitley, 1929 'gill-slits regularly decreasing in size posteriorly'. Again, lengths of 1st, 3rd, 5th gill slits recorded by Garrick (1967, table 2) for 5 examples of *I. oxyrinchus* exhibit a surprising variety of pattern when arranged in order of magnitude, namely, 1>5>3 (2 specimens), 1>3>5, 1 = 5>3, 5>1>3, while in 5 examples of *I. alatus = I paucus* (table 3) the sequences are 1>3>5, 3>5>1, 5>1>3 (2), 1>5>3.

The total system of slits is rather more than one and a half times as wide above (direct measurement in full to recurved last slit at tip 74) as below (45). In first slit upper end is directly above lower end, but becomes increasingly behind it in the rest, being in last 16, or about one-fourth length of slit, further back. The oblique line joining lower ends when produced forward reaches eye level about an eye diameter behind orbit; slope of line joining upper ends somewhat greater. In all slits except first both ends are recurved, most markedly so in fifth, where upper and lower ends extend backwards about 7,6 respectively, the lower curling right round pectoral base, ending about 8 behind the perceptible insertion of the fin, with tip of slit about 10 below level of anterior fin border. A quite different situation is presented in the illustration by Phillipps (1926, pl.87) of his New Zealand *I. glaucus* (holotype of *I. mako*), the slits there being depicted as being erect and subparallel, the last well in advance of pectoral insertion : the disposition of the slits as found in our specimen would appear to be more or less the normal one.

Dentition. All teeth without lateral cusps. In upper jaw teeth in anterior portion elongate, depressed, margins somewhat sinuous, posterior margin becoming increasingly concave, length up to two and a half times, occasionally a little more, width (at base of cusp); posteriorly becoming progressively shorter, wider, subtriangular, length subequal to basal width. On either side 12 teeth can be detected, ranging in height from 9.4 to about 3 mm or less; behind eighth tooth in either jaw an additional inner tooth, that on left considerably larger than, that on right subequal to, outer tooth. Third tooth, left 4.0, right 3.8, shorter than second, 9.0, 9.5, and than fourth, 5.6, 6.1: the fact that the third upper tooth on each side is smaller than the teeth flanking it is a characteristic of the Isuridae.

In the lower jaw 12 teeth are detectable in each ramus, long (first, right, 10.1, left imperfect), slender anteriorly, progressively shorter, relatively stouted posteriorly; interspace between first pair 9.6, between last pair about 2.5; first pair inserted well outside general line of lip, having almost the appearance of springing from the chin and curving upward towards the mouth cleft, the same being true, to a lesser degree, of next pair, set closer to general lip line and straighter (net effect, tip of jaw 'bristly'); remaining teeth with bases internad of lip line; each of main, outer row with a second tooth, in general similar, behind it; a third tooth behind the anterior two in each ramus.

Cutting edge on lateral margin of first tooth in each jaw incomplete. In upper jaw distance (mean of left and right) of third tooth from second 6.95, from fourth 11.5; in lower jaw 8.5, 10.05.

The marked irregularity in the insertion and orientation of the teeth of the lower jaw and the contrasting relative uniformity of these features in those of the upper jaw are well seen in a photograph of a New South Wales specimen reproduced by Goadby (1959, unnumbered fig., p.59): see also Garrick (1967, pl.2), in which photograph, however, the anterior teeth appear to be inserted more internad than in our example.

Other features. The general form of the shark is tolerably well specified, expressly or by implication, in the foregoing description. Some miscellaneous points not elsewhere dealt with are here noted.

Nictitans: absent (family character). *Spiracle:* either minute or absent in isurids, not detected in specimen. *Pupil:* virtually circular, in one eye a trifle more extensive vertically. *Oral groove:* at junction of lips a groove 8 long, deepest anteriorly, extending backward and slightly outward. *Labial folds:* inconspicuous, tapering, length of upper 10, lower 13. *Naris:* external angle virtually on (about 1mm from) lateral profile, overall slightly oblique inward and backward, anterior dumbbell aperture more so, oblique length 7, tragus small, wider than long, fairly acute, no cirrus. *Interdorsal ridge:* traceable as a low rounded ridge for more than half distance between fins, thereafter a median slightly depressed area widening backward to about 10 at second dorsal origin. *Lateral line:* first detectable 55 behind eye; an upwardly convex arc, chord 95, to a point 18 above interspace between third and fourth gill slits, here 30 below dorsal profile; gently convex to first dorsal termination, here one and two-thirds as far from ventral as from dorsal profile, slowly downward almost straight, about to end of ventral base, here a little below middle of flank, about 5 above junction of light and dark regions; briefly somewhat downward then almost horizontal, along line of color demarcation, to meet caudal keel, apparently ending there. *Caudal keel:* from caudal base, 55 behind origin of fin (anteroposterior extension of fin here 25) forward as a strongly scalloped flexible fold, maximum height about 5, to level of second dorsal origin, thereafter still traceable as a low, continuously lapsing ridge almost to level of hind end of ventral base, a total length of round 220; segment on fin sigmoid. *Myomeres:* from level of first gill slit to first dorsal origin 28, to second dorsal origin 75. *Pores on head:* (a) on either side of ventral surface, about midway between nostril and tip of snout, a patch, about 15 x 15 mm, of some three to four score small dark pores with slightly elevated rims, patch extending inward from margin of head to within about 5 of its fellow, the internal border inwardly convex; (b) on dorsum, in two bands, each about 5mm wide, confluent about 10 behind snout tip, diverging backward for about 60 to terminate, 15 apart, just beyond level of front of orbit; (c) below eye, about two score on each side, widely separated, minute, mostly black. *Caudal pits:* similar in general shape and in size; a shallow groove, length upper 17, lower 16, front lip gently bisinuous, coplanar with adjacent part of peduncle; followed by shallow depressed region, about 4 anteroposteriorly, decreasing in depth to its forwardly concave border; this area in lower pit somewhat paler than surrounding off-white, in upper pit blackish, concolorous with surrounding region. *Subterminal caudal notch:* below tip of fin by 26, small, depth 6, greatest (external) width about 1; immediately followed below by a curious subrectangular tuft-like process, base 5.5, extending 4 beyond general level of fin border nearby (individual variation?). *Denticles:* minute, imbricate, tricarinate, median carina stoutest, longest; median free border with spur (continuation of keel), lateral elements each with spur (usually shorter than median) or merely shouldered.

Coloration. Those parts that in life presumably were the characteristic blue from which the species derives one of its vernacular names, blue pointer, present in the preserved specimen a somewhat indeterminate color perhaps best described as gun metal: in the observations below it is recorded simply as 'dark', or, where more intense, as 'very dark'.

Head, upper surface. Above a line back from tip of snout, passing below orbit by about one-fifth of distance of orbit from upper jaw more or less straight to a little below middle of first gill slit, thence obliquely back and down to near middle of fifth gill slit in general dark, darker on much, very dark on some, of dorsum; an oblique pennon backward from eye almost to first gill slit somewhat lighter, distinctly so for about half its width in a patch behind eye, being here light greyish. *Head, lower surface.* Snout at tip for about 12 ventrally, about 20 laterally, very dark, approaching black; thereafter to a forwardly convex arc joining backs of nostrils lighter, anteriorly brownish, posteriorly light horn or whitish; on either side of this region two patches each of 3-4 score black pores, the patches separated by a dusky horn poreless strip; rest of snout back to lower lip dark or very dark greyish,

or, particularly mesially, greyish brown; between lower jaw and level of first gill slit mostly dark greyish, with a small whitish area nearer mandibular symphysis, and, on right side, a large whitish patch from lower half of first gill slit forward about halfway to mouth; area on ventral surface between the two series of gill slits with irregularly disposed patches, mostly contiguous, of whitish and greyish. *Trunk.* Above a line briefly running obliquely down from middle of first gill slit to level of pectoral insertion, at about half a snout length above it, and then descending obliquely to horizontal level of fin insertion about halfway along fin base, thereafter continuing more or less straight back along midline of side to level of second dorsal almost uniform dark; below this more or less wholly whitish. *Tail.* The whitish and dark regions on the trunk continue back without interruption on the tail, sharply divided by the frill-like caudal ridge, the upper surface of which is whitish, the lower dark.

Pectoral. Upper surface dark, concolorous with upper flank; a narrow off-white strip along whole of inner border, widening outwards towards inner angle of fin, then continuing, decreasing in width, along inner one-third of distal border; under surface mostly off-white, a band of light grey along distal border. *First dorsal.* Very dark; somewhat lighter for 5-7mm along distal border. *Second dorsal.* Mostly very dark, a little lighter posteriorly; very narrow slip of light grey along lower border of the prolongation. *Pelvic.* Upper surface whitish, proximally, yellowish distally; a rather sharply delimited oval spot, about 12 by 20, just behind anterior border; lower surface off-white. *Anal.* Almost uniform very pale greyish; a narrow slip of white along inner border. *Caudal.* Mostly dark like body, or a little less intensely so, except for a light horn-colored rim 4-6 wide along whole of posterior border, and for a conspicuous continuation of white of lower half of caudal peduncle extending back on to fin more than halfway towards its hind border, this patch ending below in a downwardly convex arc and being delimited above by the continuation on to the fin of the peduncular ridge.

Discussion.

(i) Identification of a Tasmanian mako. A point of special interest in a local context centres round *Oxyrhina gomphodon* Müller & Henle, 1838; though enjoying page priority over *Oxyrhina glauca*, this name never achieved wide usage, being treated early as a junior synonym of *Isurus oxyrinchus*, from which on the other hand *O. glauca* has traditionally been regarded as distinct. In a communication sent from England to 'Hobart Town', published in the precursor to the present journal (*Papers and Proceedings of the Royal Society of Van Diemen's Land*, 1885, 3(1), p.81) A. Cross states he identified a shark in the Society's museum, marking it *Lamna cornubica*, but he now writes 'for the purpose of having the name which I placed on the specimen altered to *Oxyrhina gomphodon*, as I should be very sorry to mislead my friends in the Southern Hemisphere'.

(ii) Assessment by keys prior to 1966. The taxonomic status of the present specimen as determined by several of the more important keys published prior to 1966 is here examined, the period covered exhibiting a general trend towards reduction in the number of species regarded as valid.

Six species were keyed by Garman (1913), two *Lamna nasus* (Bonnaterre, 1788) and *Lamna guntheri* Murray, 1884, being referred to a subgenus *Lamna*. (Murray's species with its anomalous dentition, 22/28 in each side of the jaw has long presented a problem. Interpreting the recorded count as the total tally, Smith (1957, p.92) has suggested identity with *Carcharias tigris* Atwood, 1865; Garrick (1967, p.667) accepted this interpretation of the dentition, pointing out, however, that Murray's account (1884) stressed his species has many teeth. Features other than dentition by which *L. guntheri* was held to be distinct — position and shape of fins, length of caudal keel, presence of a prominent lateral line — are not expressly discussed by Smith, and are dismissed by Garrick as having no validity). The nominate subgenus is regarded as

comprising *Lamna punctata* Storer, 1839 (distinct from *L. punctata* De Kay, 1842 = *Isurus paucus* Guitart Manday, 1966; see below), *Carcharias tigris* Atwood, 1869, *Isurus oxyrinchus* Rafinesque, 1810 and *Oxyrhina glauca* Müller & Henle, 1838. Of these the first two are excluded by the criterion 'dorsal origin above the pectorals'. As determined by position of dorsal relative to pectoral (*I. oxyrinchus* 'near a vertical from end of pectoral base', *I. glaucus* 'near a vertical from the ends of pectorals') our specimen occupies an intermediate position, dorsal origin being about from level of inner end of distal border, i.e., axilla, and level of pectoral tip (perhaps nearer *I. glaucus*). The second criterion, that of relative position of second dorsal and anal bases, is not very clearly specified in the key, but reference to the text shows anal origin is 'a short distance' behind dorsal origin in *I. oxyrinchus*, with dorsal base almost wholly in front of anal base in *I. glaucus:* the latter more nearly describes the disposition in our shark.

Noting in their key to three species that the validity of *I. guntheri* is'very doubtful' (see above), Bigelow & Schroeder (1948) separate *I. oxyrinchus* and *I. glaucus* by four criteria as follows (*I. oxyrinchus* here cited first): (a) height of first dorsal about half distance from eye to 4th gill opening, to 2nd gill opening; here 0.58, 0.44: (b) height of first dorsal greater, less than, its base; here 0.93: (c) length to pectoral origin about equal to distance from axil of pectoral to rear end of pelvic base, to pelvic origin; here 0.89, 1.04: (d) distance from pectoral axil to pelvic origin about length to 2nd gill opening, about length to pectoral; here 1.06, 0.96. Thus of four differentiae the first and last are indeterminate, while the other two favour *I. glaucus*.

Keying *I. bideni* Phillipps, 1932, *I. glaucus* and *I. mako* Whitley, 1939, Phillipps (1932) coupled the first two as having height of dorsal 3½ times or more (*v.* less than 3½) in length to first dorsal origin; in our specimen the value is large, 4.67. *I. glaucus* is characterized as having anal base (as in our specimen) partly under, instead of wholly behind, second dorsal base. Smith (1957, p.91) has expressed strong reservations regarding the taxonomic significance of relative positions of anal and dorsal as described for *I. bideni* (*cf.*, however, diagnosis of *I. paucus* and the synonymic *I. alatus*): for our specimen see above.

Smith (1957) keys off *I. glaucus* on the one hand from *I. oxyrinchus* and *I. tigris* on the other as having top of first dorsal broadly rounded, not acute (as his diagram, fig. 1, showing typical forms of adults, depicts for *I. tigris*) or acutely rounded (from diagram *I. oxyrinchus*); in ours the shape of the fin is closest to that of *I. glaucus:* however, it has now been shown by Garrick (1967) that shape of dorsal varies with age, tip becoming more pointed in older individuals. There appears to be some confusion in the key with regard to specification of vertical height of first dorsal in terms of length to (level of) pectoral origin, but if we take the figures for the number of times the first is contained in the second we get 3.1-3.5 for *I. glaucus*, 2.6-3.0 for *I. oxyrinchus*, 2-2.4 for *I. tigris:* our specimen at 3.24 comes out at *I. glaucus*. Some ambiguity exists also in respect of the ratio of height to base in the first dorsal, but reference to the general text and to fig. 1 makes it evident height is equal to, or less than, base in *I. glaucus* (in our specimen less), greater than in the two other species (a scatter diagram presented by Garrick (1967, fig.4) shows the ratio base/height of fin correlated negatively with total length). Length to pectoral origin as compared to interval between hind margin of pectoral base and pelvic origin is given as 'not or a little more' in *I. glaucus*, 'usually distinctly more' in *I. oxyrinchus*, 'usually distinctly less' in *I. tigris;* our value, 1.04, is in best agreement with *I. glaucus*. Values, as percentages of length to origin of upper caudal lobe, of lengths from snout tip to fin origins and terminations as read off from fig. 1 (estimates accurate to round about 1%) in 'typical forms of adults' of *I. glaucus*, *I. oxyrinchus*, *I. tigris*, in that order: first dorsal origin 45,44,47 (ours 46.8), first dorsal termination 55, 54, 58 (57.6), second dorsal origin 88, 83,

87 (88.0), anal origin 90, 83, 87 (89.4), pectoral origin 30, 31, 29 (32.5), pelvic origin 69, 63, 70 (69.8). In these 6 dimensions the Tasmanian specimen comes closest to *I. glaucus* in 2, to *I. oxyrinchus* in 1, to *I. tigris* in 3. However, the extent of the variation throughout is probably not sufficiently great to be of taxonomic significance. For the 4 variates the coefficients of variation (s calculated with degrees of freedom $n + 1$) are 2.1-4.3: it is found by experience that in most comparable contexts a population homogeneous for species, age (sex if relevant) is likely to yield $V \leq 10$, modally round 5.

Though Garrick & Schultz (1963) recognize in the text only *I. oxyrinchus* and 'a second oceanic species in the Pacific, characterized by having considerably longer fins' (species twice described in 1960's; see below), they give separate figures of the 'Atlantic mako shark, *Isurus oxyrinchus*' (fig. 5) and the 'Pacific mako shark, *Isurus glaucus*' (fig. 6). Noticeable differences include (*I. oxyrinchus* taken as standard): first dorsal higher, relative to its base, much more pointed, its distal margin less deeply excavate; lower caudal lobe longer, relative to upper, fin thinner with most anterior point on hind border closer to level of origin of upper lobe. In these characters of dorsal and caudal our example approaches more closely fig. 6 *(I. glaucus)*.

(iii). Assessment in terms of Garrick's 1967 revision of the genus. In his recent admirable revision of the genus *Isurus* Garrick (1967) after reviewing the status of the following nominal species, *Isurus oxyrinchus* Rafinesque, 1810, *Isurus spallanzani* Rafinesque, 1810, *Squalus (Lamna) cepedii* Lesson, 1830, *Oxyrhina gomphodon* Müller & Henle 1838, *Oxyrhina gomphodon* Müller & Henle, 1838, *Isuropsis dekayi* Gill, 1862, *Carcharias tigris* Atwood, 1869, *Lamna guntheri* Murray, 1884, *Lamna huidobrii* Philippi, 1887, *Isurus mako* Whitley, 1929, *Isurus bideni* Phillipps, 1932, *Isurus africanus* Smith 1957 concluded these all relate to a single species, *Isurus oxyrinchus* Rafinesque, 1810. (The spelling of the second binomen has been emended by Garman (1913) and some other authors to *oxyrhnchus*, and this action has been defended by Tortonese (1956, p.106, fnt 1) on the ground that the original spelling was an 'inadvertent error' in terms of Article 19 of the Code, and hence requires emendation to the etymologically expectable form; Garrick, however (1967, p.665) considers the text affords no evidence such an error is involved.)

Whilst from the beginning it might have been expected by an independent observer that some of the characters on which nominal species have been based may be growth dependent, little contemporary evidence of such variation was available, and from time to time a new species has been established on proportional differences of form on a single individual. Garrick has now examined 35 specimens for which fairly complete measurements were taken and 8 for which only incomplete data were available; these data being supplemented by some proportions from published descriptions and illustrations.

Scatter diagrams show the position in regard to correlation of certain features with total length is as follows: (a) no clear correlation (among the traditional 'short-finned' forms, i.e., excluding *I. alatus* = *I. paucus*) for length of anterior margin of pectoral as percentage of prepectoral length (fig. 1), or for length of anterior margin of pectoral as percentage of total length (fig. 2); (b) positive correlation for the ratio base/height of first dorsal (fig. 4), and for the ratio prepectoral length/height of first dorsal (fig. 5). With abscissal coordinate (total length, mm) 857 throughout (close to diagram's origin at a little less than 600), and with ordinal coordinates for figs 1-5 of 68.4, 20.6, 8.2, 1.07, 3.2, respectively, our values are in general in good agreement with the plotted points, least so in the case of fig. 2, where our value of 20.6 is noticeably higher than any of the 12 points for $Lt \geq 1\,600$, though it is equalled or exceeded by later entries. Several other correlations between total length and relative dimensions (percentages of *Lt*) or ratios not expressly noted by Garrick can, as he observed, be gathered from his tables 1,2.

Of the ten proportional dimensions set out in table 1 for three size classes, *Lt*, mm 605-1 400, 1 401-2 200, 2 201-3 200, mean values show progressive increase with increase of overall size in two instances, (a) pectoral axil to pelvic origin as % of *Lt* (17 specimens) and (b) pectoral origin to first dorsal origin/back of eye to first gill (19), and progressive decrease in one (c) back of eye to third gill/first dorsal height (18); there is, however, considerable overlap in all cases (range only recorded, no other measure of dispersion). Our values (range and mean for *Lt* 605- 1 400 group in parentheses) are (a) 25.5 (20.7-27.6, 23.5), (b) 1.26 (0.70-1.38, 0.98), (c) 1.82 (1.74-2.20, 1.98). In spite of the existence of such correlations, indicative of allometric growth, as those noted above, the data of tables 1,2 would seem clearly to indicate that some conventionally recorded dimensions and proportions, while subject to noticeable variation, are not functions of size. Garrick encountered no sexual dimorphism in proportions.

(iv) Comparison with *Isurus paucus* Guitart Manday, 1966: Though the existence of 'a second oceanic species in the Pacific, characterized by having considerably longer pectoral fins' was noted by Garrick & Schultz in 1963 (see above), it was not till 1966 that this form received its present name of *Isurus paucus* Guitart Manday. Though Guitart Manday's account is based on actual material from Cuban waters - male 2 260, male 2 030, female 1 955 mm from snout tip to precaudal pit; the third designated 'ejemplar selectionado', but pectoral of second illustrated in fig. 2 - his name is proposed as a *nomen novum* for *Lamna punctata* De Kay, 1842, from New York, preoccupied by *Lamna punctata* Storer, 1839, which is a different species, namely, *Lamna nasus* (Bonnaterre, 1788). He considered references to this species occur scattered through the literature, his table of synonymy comprising 12 entries, specimens being variously referred to *Oxyrhina (O. glauca)*, *Isurus (I. glaucus, I. dekayi, I. tigris, I. oxyrinchus)* and *Isurus (I. dekayi, I. glaucus)*, a dozen authors or author groups being involved.

The description of *I. paucus* (second binomen having reference to fewness of specimens — probably attributable partly to the species being oceanic, and partly to its likely occurrence, suggested by the eyes being somewhat larger than usual, in rather deep water) appeared while a description of the same form by Garrick under the name of *Isurus alatus* (second binomen having reference to the specially long pectorals) was in press (holotype male, paratype female, male from 'tropical Indian or Pacific Oceans', supplementary material from tropical Pacific). Garrick notes only two entries in his synonymy: *Isurus glaucus:* Strasburg (in part, 1958, p.357) and *Isurus oxyrinchus:* Fourmanoir (in part, 1961, p.79).

The accounts of Guitart Manday (1966, pp.1-9, figs 1-3) and Garrick (1967, pp.677-687, 689-690, pls 1-4) agree in distinguishing their species by three main features: (a) length of pectorals, (b) relative positions of second dorsal and anal, (c) coloration; both call attention to the character of the dentition, and these are possible further differences in shape of caudal, size of pelvics, depth of body.
(a). Guitart Manday (table 1) gives length of pectoral as percentage of length to precaudal pit in *I. paucus* (3 examples) as 30.4, 30.0, 29.2 and in *I. oxyrinchus* (8) as 21.0-23.9 ($\bar{x}$ 22.3), while lengths as percentages of total length from Garrick (tables 1,2) are in *I. alatus* (5) 24.4-26.5 ($\bar{x}$ 25.98) and in *I. oxyrinchus* (5) 16.4-18.4 ($\bar{x}$ 17.32): in our shark the first value is 20.6, the second 16.8, i.e., within Garrick's and barely outside Guitart Manday's range for *I. oxyrinchus*. Guitart Manday institutes also a comparison of length of pectoral with length of upper caudal lobe, finding (table 2) for *I. paucus* 107.7 and for *I. oxyrinchus* (8) 80.1-94.6 ($\bar{x}$ 88.6); Garrick's tables yield 113.6-124.4 ($\bar{x}$ 119.5) and 80.0-86.7 ($\bar{x}$ 84.0); our specimen 80.0.
(b). Both *I. paucus* and *I. alatus* are described and figured as having anal base immediately behind second dorsal base. In the Tasmanian specimen anal originates under 0.78 of second dorsal base.
(c).'The dusky coloration on the underside of the snout of *I. alatus* contrasts strongly

with the immaculate whiteness of this region in *I. oxyrinchus*' (Garrick, p.678): the text goes on to note that the duskiness increases in both extent and intensity with age. In respect of this feature our specimen is quite anomalous, wholly departing from the above (and the general) specification for the short-finned species, and being on the contrary in good agreement (see notes on coloration above) with that for the long-finned species.

Guitart Manday points out that in the teeth of the upper jaw the posterior margin is flatter in *I. paucus;* however, his figure (3 C,D) shows the tooth of *I. paucus* more slender than that of *I. oxyrinchus,* in direct disagreement with both the statement and figures (8, 9) of Garrick, with which latter our material is in accord.

While Garrick's figure shows upper caudal lobe about 1.43 lower lobe (from his table 1.20-1.39, $\bar{x}$ 1.29: *cf.* *I. oxyrinchus* 1.22-1.43, $\bar{x}$ 1.37) Guitart Manday's figure shows about 1.27 (his measurements 1.35); values for Bigelow & Schroeder's figure (1948, fig. 18) about 1.30 for *I. oxyrinchus* (their measurements 1.33, 1.30); Müller & Henle's figure (1838, pl.29) of type of *I. glaucus* about 1.52; our value high, 1.64; see also above, in particular note on figures by Garrick & Schultz (1963, figs 5, 6) labelled *I. oxyrinchus* (about 1.33) and *I. glaucus* (about 1.44): the relation does not appear to be diagnostic. However, Garrick figures and comments on a relatively prominent terminal lobe of the dorsal lobe together with a particularly developed notch; these features, which may be age dependent, are evident, though to a lesser degree, in the figure of *I. paucus* by Guitart Manday. In our specimen these features show a moderate development. Attention may be called to the tuft-like process below the lower border of the subterminal notch in the Tasmanian shark, the nature of which remains uncertain.

Garrick reported'In *I. alatus* the anterior margin of the pelvic fin is equal to or only slightly shorter than the distal margin, whereas in *I. oxyrinchus* the anterior margin is notably shorter'. Values of the ratio distal/anterior border for 2 examples of *I. alatus* are 1.00, 1.10, and for 5 examples of *I. oxyrinchus* 1.08-1.53, $\bar{x}$ 1.29: the data are thus scanty and the sets intersect. In our specimen the lengths of the anterior margins and the distal margins differ on the two sides (left 42mm, right 39), the ratio of the latter to the former being left 1.62, right 1.24.

Garrick was inclined, with some reservation, to consider *I. alatus* the more slender species. From his tables we find depth at pectoral as percentage of total length in *I. alatus* (4 specimens) 11.0, 12.5, 13.2, 11.8, in *I. oxyrinchus* (4) 15.3, 13.0, 12.9, 11.6 (Bigelow & Schroeder 11.3, 11.9). Thus while there is a difference in the means of Garrick's data (12.13, 13.20), only one example of *I. oxyrinchus* lies outside the range of *I. alatus,* and, on available data, the suggested distinction appears to be a doubtful one. Our specimen, 14.1.

Guitart Manday stated the eye of *I. paucus* is one-third of preoral length (type, *Ls*1 955), while Garrick observed of eye of *I. alatus* it is 'slightly larger at all sizes than that of *I. oxyrinchus*'. Since relative size of eye decreases with age, little is gained by direct comparison of data for the two species in his tables (specimens of *I. alatus* on the average noticeably larger); however, when the relevant *Lt* percentage values are plotted against *Lt* a clear distinction becomes apparent. The 5 entries for *I. oxyrinchus* show a progressive decrease with increase in overall length, and the plotting of these coordinates as y, x, respectively, exhibits a good approach to linearity ($y = -0.000735\ x + 2.98$; $t = 7.110$*); a slightly better fit being obtained when log *Lt* is plotted ($y = 2.1396 \log x + 8.6006$; $t = 8.496$*). Our value is 2.22; as predicted by the two equations above 2.35, 2.33.

It should be noted that numerical results from Garrick's paper cited above are subject to some possible slight error, his tables 1, 2, from which these are derived,

setting out, not absolute measurements, but values calculated as percentages of total length (standard length would perhaps have been appropriate).

Definitive determination. The Tasmanian shark here described is clearly to be referred to *Isurus oxyrinchus* Rafinesque, 1810. However, in its possession of extensive and intense dark mental and gular pigmentation it exhibits a character hitherto believed to be diagnostic of the only other species of *Isurus* now generally recognized, *I. paucus* Guitart Manday, 1966.

Family MELANOSTOMIATIDAE

Of the six families of Stomatoidei generally recognized (Greenwood *et al.*, 1966) two, Melanostomiatidae and Malacostidae, have not hitherto been reported from Australia, though one species of the latter, *Malacosteus niger* Ayres, 1849, is recorded (Munro 1967) from off New Guinea. In May 1977 the Queen Victoria Museum, Launceston received a stromateoid fish taken from the alimentary canal of a deep-sea trevalla, *Hyperoglyphe porosa* (Richardson, 1845) caught off the east coast of Tasmania: the specimen was secured before digestion was well under way and was readily recognizable specifically. The literature needed for its identification not being available in Launceston, Dr J.R. Paxton, Curator of Fishes, the Australian Museum Sydney, kindly undertook to examine the specimen, and determined it as *Echiostoma barbatum* Lowe, 1843. In returning the specimen Dr. Paxton forwarded also, from the Museum's collection, two other examples taken in Australian waters, suggesting records of these might appropriately be included in a report on the Tasmanian specimen. The writer is deeply appreciative of Dr Paxton's courtesy in making the identification and in providing relevant literature. The range of *Echiostoma barbatum* is given by Morrow & Gibbs (1964) as 'Gulf of Mexico, Caribbean Sea, North and South Atlantic Ocean as far north and east as Madeira, as far south as Capetown'. The species occurs in the central Pacific, Indian Ocean (Legand and Rivaton 1967) and just north of New Guinea (Fourmanoir 1970) and may thus be said to be widely distributed in tropical waters (Parin 1968, Parin and Sokolovsky 1976 and Parin *et al.* 1976).

Genus *ECHIOSTOMA* Lowe, 1843

Echiostoma Lowe, 1843, *Proc. Zool. Soc. Lond.*, 2, p.88. Type-species, *Echiostoma barbatum* Lowe, 1848.
Hyperchoristus Gill, 1884, *Proc. U.S. Nat. Mus.*, 6, p.256. Type-species, *Hyperchoristus tanneri* Gill, 1884 (= *Echiostoma barbatum* Lowe, 1843).

Echiostoma barbatum Lowe, 1843

Echiostoma barbatum Lowe, 1843, *Proc. Zool. Soc. Lond.*, 2, p.88. Type locality: Madeira.
Echiostoma barbatum: Morrow & Gibbs, 1964, *Mem. Sears Found. Mar. Res.*, 1(4), p. 482 (synonymy and references, p.486); Krueger & Gibbs, 1966, *Copeia*, 1, p.43 (synonymy and references).

Material. Three specimens: (a) *Ls* approx. 44, *Lt* approx. 50, Port Kembla, New South Wales, F.R.V. *Kapala*, 22 July 1974, 125 fm (230 m), Australian Museum Sydney Reg. No. 1. 18 173 - 028; (b) *Ls* 144, *Lt* 156 (?+), off Paddy's Head, north of Bicheno, east coast, Tasmania, P. Armstrong, 7 May 1977, in alimentary canal of *Hyperoglyphe porosa* (Richardson, 1845), Queen Victoria Museum Reg. No. 1977/5/20; (c) *Ls* 265, *Lt* 286, off coast of Queensland or New South Wales, R. Pine, March 1971, Australian Museum Sydney Reg. No. 1. 19 386 - 001.

Proportions. In the next paragraph proportions of specimens (b) and (c) are recorded in accordance with the schedule adopted by Morrow & Gibbs (1964) in the presentation

of data on 16 examples, *Ls* 27.2-323 mm (including types of four nominal species or subspecies), their range and mean values being noted in parentheses. Entries are given either as a percentage of standard length (without notation) or as a percentage of head length (marked *HLh*). Specimen (a) is rather strongly contorted and good measurements cannot be made on it.

Depth of body 12.8, 15.8 (10.2-16.8, 12.3). Length of the postocular organ (in present specimens the measurement — following the procedure of Krueger & Gibbs (1966) — is the greatest length of the light-colored portion, and does not include the black tissue surrounding, and closely applied to, the light portion), *HLh*, 37.9, 25.0 (10.2-34.2, 22.0), or 147.1, 201.3 (50-216, 77.0) percent of eye. Length of head 13.9, 16.0 (14.0-17.1, 15.6). Depth of head 12.5, 12.8 (9.5-11.1, 10.5), *HLh*, 85.0, 80.0 (62.6-75.4, 69.1). Snout 1.18, 2.12 (2.7-4.3, 3.3), *HLh*, 27.0, 21.2 (17.9-25.2, 21.5). Eye 2.36, 3.02 (2.2-3.2, 3.3), *HLh*, 17.0, 18.8 (14.2-21.2, 17.1). Interorbital 4.86, 6.79 (5.2-6.2, 5.6), *HLh* 35.0, 42.4 (-, -, -). Base of dorsal 8.08, 7.55 (6.7-9.8, 8.7). Base of anal 8.75, 8.68 (9.2-12.1, 10.5). Length to dorsal origin 86.0, 85.7 (80.9-85.2, 83.1). Length to anal origin 87.5, 86.8 (82.0-85.8, 83.4). Length to pelvic origin 61.1, 61.5 (55.6-62.6, 59.0). It will be seen some entries for one or both of the present specimens fall outside the range recorded by Morrow & Gibbs; however, these variations do not appear to be of particular significance.

Some additional proportions may be noted (all as percentages of standard length). Length to barbel 3.5 (middle of base), 4.2 (middle of socket). Length of barbel 12.5. -. Length to vent (middle 80.5, 84.9. Depth (in parentheses width) at front of eyes 7.6, 6.4 (4.9, 5.5), back of eyes 9.4, 8.3 (6.3, 6.2), end of mouth cleft 11.8, 12.8 (6.3, 5.5), pelvic origin 9.7, 12.1 (3.5, 3.2), vent 6.3, 7.5 (2.6, 3.2); maximum 12.8, 15.8 (6.3, 6.2); depth of caudal peduncle 2.7, 2.3: some dimensions of width may have decreased as the result of preservation. Longest ray, dorsal 5.6, 4.7, anal 5.9, 5.1, pelvic 13.2, 12.1. Isolated pectoral ray 22.9, 32.1 (Krueger & Gibbs (1966), with 40 specimens, *Ls* 51.1-281.7, record 19.6-48.7); other pectoral rays (b) 4.2, 4.9, 5.6, (c) 4.5, 6.2, 7.0. Length (oblique) of upper jaw 13.9, 14.5, of lower jaw 12.5, 13.2. Length of mouth cleft between parallels 11.1, 11.7.

Meristic characters. Ranges of Atlantic examples given by Morrow & Gibbe (1964) are noted in parentheses: Parin & Sokolovsky (1976) have recorded comparable counts in material from the Kurisho Current zone in the western Pacific. D. 11, 11 (11-14). A. 13, 13, 13 (13-18). P. 1 + 3 (1 + 3). V. 8 (8). Serial photophores: *IP* 8 + 2, 8 + 2 (8 + 2), *PV* 26, ca 25 (28), *VAV* 16, - (14-16), *AC* -, - (12-13), *OV* ca 26, ca 24 (24-27), *VAL* 12+, - (13-17): no data for (a).

General observations. (a). Dentition. While the general dental plan is that typical for the species, several variations on published accounts occur: some differences are found between the two specimens and between the two sides of a fish. Premaxillary teeth: (b) 11/8 (left/right) curved barbed fangs, (c) 12/13; (b) 3rd, 5th,3rd, 5th smaller, inserted externad of neighbours, 1st, 3rd, 5th, 6th/3rd, 5th, 6th, 7th rigid; (c) 4th, 7th, 8th/7th, 8th smaller set externally, 1st, 2nd,4th/1st, 3rd rigid. Maxillary teeth: (b) 4/2, (c) 7/6 all small, depressible; (b) 16/16, (c) 36/31 minute denticles along sharp ventral edge of posterior portion. Mandibular teeth: all depressible, (b) 8 (4 large)/7 (3 large) moderate or large fangs (2 very small at base of 7th left), (c) 14 (9 large)/13 (8 large); (b) 8/4 smaller teeth in 2/2 rows, (c) 20/15 in 2/2-3 rows (in left jaw these smaller teeth extend forward outside larger teeth to 5th larger). Vomerine teeth: in both specimens 1 moderate, backwardly directed depressible tooth at each outer angle. In both specimens palatine with a single anterior tooth; after a diastema (b) 4/3, (c) 6/6 other teeth of subequal size. On first basibranchial (b) 1 + 2, (c) 1 + 2 + 2; on second basibranchial (b) 1 + 1 + 1, (c) 1 + 2 + 2, on both basibranchials increasing in size backward to large, in all cases first unpaired tooth on left side. In (c) a few minute teeth, not observed in

(b), occur on the first branchial arch. Two contiguous clusters each of 6 fairly stout somewhat recurved teeth are present in (b) on the roof of the oral cavity just behind the level of the end of the mouth cleft; these are not apparent in (c), and are not expressly noted in the published accounts of the dentition at hand.

(b). Cranial spines. Morrow & Gibbs observe 'interorbital nearly flat, with a spiny ridge above each eye, the ridges meeting anteriorly to form a V'. In none of our 3 specimens do the ridges quite meet, being briefly separated by the interposition of the origin of a forwardly directed median ridge. In (b) the structure on each side consists of two ridges of approximately equal anteroposterior extent (about one and a half eye diameters), the hinder bowing outwards markedly at its anterior end, with the front segment originating well inside this curve and running forward, about in the same sense as the straight portion of the hind segment, to about the middle of the snout. On each side the ridge (composite or single) is beset with 9-13 small, compressed, pungent, mostly forwardly directed spines. Other spines on the head include: (i) shortly behind, and externad of, each of the ridges just mentioned a short line of 3 spines running backward and outward; (ii) an arc of several spines pointing forward and a similar set overhanging the eye, all arising from an ovoid bony lamina on the orbit near 10 o'clock (left side viewed); a similar group near 3 o'clock.

(c). Barbel. The structure is missing in (c); its position being marked by a conspicuous socket in the form of a deep groove bounded laterally and behind by thick subtranslucent walls of cartilaginous appearance and consistency, and ending anteriorly at a small fleshy knob, probably part of the barbel stem, the fairly firm off-white tissue marked on its flattish distal surface by 8 blackish well-rounded spots, and largely sheathed in thin black integument. In (b) the stem is somewhat flattened proximally, becoming more rounded and increasingly slender for some 15 mm; proximal bulb ovoid, about 2 mm long, more than twice as long as wide, pale orange with blue longitudinal line; next a somewhat flattened segment of comparable length, but narrower, more than half its width occupied by a continuation of the blue streak, rest white (this segment with the appearance of being a stout cord issuing from the concave end of this region), the narrowing distal end followed by two elongate bulblets, side by side, their free ends secondarily bulbous; arising from this region a small lateral bulblet and two filaments, the shorter with its termination minutely bulbous. In (a) the barbel has a total length subequal to that of head. It comprises: a stout stem successively flesh-colored, dark brown, dusky, and, very briefly, yellowish; proximal bulb large, ovoid, arising directly from stem, brownish; distal bulb transversely ovoid, slightly flattened, about two-thirds first bulb, light brown; attached to distal end a group of three small subequal yellow bulblets and two fine terminal filaments, one golden, one, a little longer, subequal to length of proximal bulb, brownish.

Together with size of postocular organ, the structure of the bulb has provided the basis for the establishment of *Hyperchoristus tanneri* Gill, 1884, *Echiostoma ctenobarba* Parr, 1927, *E. guntheri* Regan & Trewawas, 1930, *E. calliobœrba* Parr 1934, and *E. ctenobarba ramifera* Parr, 1934. Studies of long series of specimens has confirmed the existence of only a single species of *Echiostoma*, *E. barbatum* Lowe, 1843, changes in the form of the barbel occurring more or less regularly with age (Morrow and Gibbs 1964, fig. 135, Krueger & Gibbs 1966, fig. 1). While the absence of lateral filaments on the stem in (a), *Ls* about 44 mm, is normal for a specimen of this size, the plain stem of (b), *Ls* 144, is noteworthy, Krueger & Gibbs having found 1-4 filaments on each side near the distal end of the stem in individuals of *Ls* 112-118, increasing to 12-22 at *Ls* about 200: there is of course a posibility lateral stem filaments may have been present in (b), but have been digested off.

(d). Other features. (i) Isolated pectoral ray. Morrow & Gibbs state cleared and stained material shows the isolated first pectoral ray to be composed of 2 rays in a single sheath, with a minute subdermal ray in front of them, all arising from a single

actinost. In both (b) and (c) the existence of two elements in a common membrane is clearly evident in the proximal portion of the process. (ii) Sex. In their investigation of sexual dimorphism in this species Krueger & Gibbs have found that in individuals of *Ls* ≥ 225 the sex may be determined, with a high degree of probability, by the shape of the postocular organ, which in males of this size has the form of an elongated triangle, whereas in females it retains the pyriform outline characterizing the young of both sexes. On this basis (c) is clearly a male. (iii) Paired light organ. In both (b) and (c) a small white subcircular light organ occurs at the angle of the deep notch between the operculum and the fluted and crenulate subopercular.

Coloration. General color of (a) dark brown approaching black. Dorsal, anal pelvic, caudal fawn, some dorsal rays with indications of spaced russet cross bars. Postocular organ grey. Inside of mouth black. General color of (b) almost uniform dead black. Dorsal and anal rays and the three grouped pectoral rays greyish, reddish brown cross bars marking the septa, isolated pectoral ray dusky proximally, becoming somewhat lighter distally, lacking pronounced markings. Inside of mouth black. Serial photophores white. General color of (c) mole, rather darker on right side; darkest on occiput and immediately behind head on lower half of body; some darkening behind level of pelvic, least developed along middle of side; indications of a narrow dark streak from occiput along side, more or less following dorsal profile to about level of dorsal origin; whole of body and much of head with numerous small dark spots. Fins mostly light brown with reddish brown cross bars. Postocular organ light yellow. Inside of mouth dark brown. Serial photophores bluish, mostly with more or less definite dark annulus.

Location of fin origins. When lengths, L, along anteroposterior axis of fish to the origins of the pectoral, pelvic, dorsal, caudal fins are graphed against N, the natural numbers 1, 6, 8, 10 in a loglog plot, a significantly straight line is obtained. For (b) the regression equation is $\log L = 0.8622 \log N + 1.2958$; $t = 33.043$ ***; measured (estimated) lengths, mm, 19.9 (19.9), 88.0 (92.6), 123.9 (118.7), 144.0 (143.9). For (c) $\log L = 0.9076 \log N + 1.5362$; $t = 19.773$ **; lengths 34.2 (34.4), 163.0 (174.7), 247.0 (226.9), 265.0 (277.8).

Family GONORYNCHIDAE

Genus *GONORYNCHUS* Scopoli, 1777

Gonorynchus Scopoli, 1777, INTROD. HIST. NAT., p. 450. *Ex* Gronow, 1763, non-binomial. Type-species, *G. gonorynchus* Meuschen.

Rhynchana Richardson, 1845, ZOOL. VOY. EREBUS AND TERROR, FISH., p.45. Type-species, *R. greyi* Richardson.

Gonorynchus greyi (Richardson, 1845)

Rhynchana greyi Richardson, 1845, ZOOL. VOY. EREBUS AND TERROR, FISH., p.45, pl. 25, figs 1-6 and one text fig. Type locality: Western Australia.

Remarks. This species, found in all Australian states (and, if *G. forsteri* Ogilby, 1911 is not distinct, in New Zealand), appears in all published Tasmanian lists, and earlier in the MS list of Allport, on which Johnston's first catalogue (1883) was based. While the original spelling of the generic name is retained in the Check-list (McCulloch 1929) and was regularly employed by Whitley (1962, 1964, 1968), the emendation to *Gonorhynchus* proposed by Cuvier (1816, p.196) has been adopted in all local lists (Johnston 1883, 1891, Lord 1923, 1927, Lord & Scott 1924) and in a number of recent Australian texts (e.g., McCulloch & Whitley 1925, Munro 1956b, Marshall 1964, Scott *et al.*, 1974), and is accepted (in the form of the family name) by Greenwood *et al.* in their provisional classification of living teleosts (1966). In

Tasmania this species is usually known by the vernacular name of Beaked Salmon (Lord, Lord & Scott) but is also spoken of as the Sand Eel (Johnston); Marshall (1964) notes both these are used in some other States, adding Mouse-fish (Southern Queensland, New South Wales) and Rat fish (Western Australia), while Scott *et al.* in their South Australian Catalogue give Sand Fish.

Material. The present observations are based on an example, (a), *Ls* 215.5, *Lt* 241.5 , taken by Mr Shane Downe in 32 fm (about 60m) at Eddystone, east coast, 10 July 1977 (Q.V.M. Reg. No. 1977/5/29), and an example, (b) *Ls* 240, *Lt* 273, collected by Mr Charles Andrews at George Town, north coast, in 1939 (Q.V.M. Reg. No. 1939/0053).

Dimensions as *TLs*. In this species some commonly recorded proportions exhibit wide variation — thus the Handbook (Munro 1956, p.28) gives depth 9-14.8, head 5-6.3 in length without caudal (in our specimens, 9.4, 8.0; 4.9, 5.1). The principal dimensions of our examples are here noted, given as permillages of standard length; smaller individual recorded first.

Length to dorsal origin 689,696, termination 763,771; to anal origin 828,848, termination 884, 919. Length to pectoral origin, front of base 200,203, insertion of rays 209,221; length of fin, from front of base 148,171, from insertion of rays 125,158. Length to pelvic 647, 688; total length of fin 111, 109. Length to vent 817,835. Head 205.198. Snout 74,78. Eye 44,35. Interorbital 41,49. Length to mouth, front 43,42, back 58,54; width of mouth 19,20. Depth (in parentheses width) at front of eye 65 (58), 56 (60), back of eye 74 (67), 69 (66), operculum 95 (104), 117 (96), pelvic origin 97 (88), 108 (77), vent 77 (60), 88 (63); maximum 107 (head 104, trunk 102), 125 (head 96, trunk 98); caudal peduncle 52 (16), 54 (14).

Meristic characters. D. 12, last divided to base; 10, last divided to base. A. 9, last divided to base. V.IV.P.10, 11. C. 20.

Location of unpaired fins. The dorsal and anal fins are set far back: in the course of the handling of Mr Downe's specimen the impression was gained that there subsists an exponential relation between their location and overall length of fish. The plots of the logarithms of the four measurements length to origin of dorsal, to origin of anal, to origin of caudal *(Ls)*, end of caudal *(Lt)* on logs 7,8,9,10 were found to be virtually collinear with each other and also with the plot on log 1 of log length to back of mouth. The relevance of the last dimension in a set of which all the other members involve fins is not apparent: trial was made of it here on purely pragmatic grounds, it having been found earlier, in a number of species of sharks, to be appropriately incorporated in similar fin plots. With L = length from the tip of snout to designated point on anteroposterior axis of fish and N = appropriate natural number the equation thus is $L = bN^k$, rectifiable as $\log L = k \log N + \log b$. The best straight line (sum of squares of logarithmic, not arithmetic, deviations minimized) for specimen (a) is highly significant, with $t = 103.953$***. With L measured in millimetres and N the relevant member of the set {1,7,8,9,10} the equation is $\log L = 1.2746 \log N + 1.1056$, giving estimated (in parentheses, measured) lengths as follows, 12.8 (12.8), 153.2 (148.5), 180.6 (178.5), 210.0 (215.5), 240.0 (241.5). The equation for (b) also is highly significant, with $t = 171.395$***: $\log L = 1.3225 \log N + 1.1130$; 13.0 (13.0), 170.5 (167), 202.5 (203.5), 237.1 (240), 272.6 (273).

Location of paired fins. The insertions of the paired fins are similarly located at what may be termed integral nodes, represented by natural numbers along a logarithmic scale. As for the fins, that scale covers the range 1-10. Again as before, the anterior point on the morphological scale is provided by back of mouth, and the posterior point remains a morphologically significant terminal entity, being here, however, not the end of the whole fish, but the end of the precaudal region. With L = length to a member of the set {back of mouth, pectoral origin, pelvic origin, vent}

and N = relevant member of the set {1,3,8,10} the best straight line for specimen (a) is log L = 1.1423 log N + 1.1079; t = 153.988***; estimated (measured) lengths 12.8 (12.8), 44.9 (45.0), 137.9 (139.5), 177.9 (176.0): for (b) log L = 1.2021 log N + 1.1145; t = 34.520**; 13.0 (13.0), 48.8 (48.5), 158.5 (165.0), 207.3 (200.5).

It will be seen the correspondence between predicted and measured values is in both cases quite good, and it would seem probable the exponential relation as formulated, like that for the paired fins, specifies a definite pattern of fin placement in this fish, the natural numbers here represented by their logarithms being characteristic at species (or genus) level, the magnitude of the numerical parameters being correlated positively with overall length of specimen.

Family ANTENNARIIDAE

Only a single antennariid is credited to Tasmania in the Check-list (McCulloch 1929), *Trichophryne mitchellii* (Morton, 1897), described from this State and since found in South Australia, Victoria and New South Wales. In Part II (1935, p.71, pl. 5, fig. 2) an example from the Tamar Heads, north coast, of the widely distributed *Rhycherus filamentosus* (Castelnau, 1872) was noted and figured: it has since been taken here on several occasions. A third species, *Echinophryne crassispina* McCulloch & Waite, 1918, previously known only from South Australia and Victoria, is here added to the local list. The following key will serve to separate the Tasmanian representatives, all of the subfamily Antennariinae.

KEY TO ANTENNARIIDAE RECORDED FROM TASMANIA

1. Skin smooth. Body with numerous fleshy processes (some branched). First dorsal spine smooth; illicium large, including two vermiform processes. Third dorsal spine mobile, rodlike. Second and third dorsal spines with fleshy processes. Size larger, to about 0.25 m ..... *Rycherus filamentosus*

   Skin with spines or bristles. Body without fleshy processes. First dorsal spine spiny; illicium small, filamentous or a group of small spines or processes. Third dorsal spine enveloped in skin, knoblike. Second and third dorsal spines without fleshy processes. Size smaller, to about 0.15 m 2

2. Dorsal rays 13-14. First dorsal spine rodlike, slender, as long as, or longer than, dorsal rays. Second dorsal spine similar to first, its length < 3 in soft dorsal base ..... *Trichophryne mitchellii*

   Dorsal rays 15. First dorsal spine rather stout, shorter than dorsal rays. Second dorsal spine stouter than first, conical, wholly enveloped in skin, its length > 3 in soft dorsal base ..... *Echinophryne crassispina*

Genus *ECHINOPHRYNE* McCulloch & Waite, 1918

Echinophryne McCulloch & Waite, 1918, *Rec. S. Aust. Mus.*, 1(1), p.66. Type-species, *Echinophryne crassispina* McCulloch & Waite, 1918.

Echinophryne crassispina McCulloch & Waite, 1918

Echinophryne crassispina McCulloch & Waite, 1918, *Rec. S. Aust. Mus.*, 1(1), p.67, pl. 6, fig. 2. Type locality: Spencer Gulf, South Australia (holotype), Western Port, Victoria (paratypes).

Echinophryne crassispina: McCulloch, 1929, *Mem. Aust. Mus.*, 5(3), p.408: Schultz, 1966,

U.S. Nat. Mus. Bull., 202(3), p.140: Scott, Glover & Southcott, 1974, MAR. FRESHW. FISH. S. AUST., p. 298, unnumbered fig. on p.299.

Material. A specimen, *Ls* 44, *Lt* 57, east coast of Flinders Island, Bass Strait, September 1974, Mr J. O'Shea, Queen Victoria Museum Reg. No. 1975/5/13.

Meristic characters. D. I, I, I, 15. A.9. P.11. V.5. C.9.

Proportions. No set of measurements of this species appears to be available. The following entries are all expressed as permillages of standard length; 'length to' connotes length from most advanced point (chin), which is in front of tip of upper jaw by 2 mm. Total length 295. Length to first dorsal spine 73, second dorsal spine 104, origin, termination of mounded base of third spine 266, 386. Length to origin, termination of soft dorsal 455, 966, of anal 761, 989. Length of first dorsal spine 161, second dorsal spine 136. Height of third dorsal spine above its posterior insertion 45; basal diameter, longitudinal 148, transverse 91. Length of longest dorsal ray 132, last ray 116; longest anal ray 136, last ray 45. Length to origin of pectoral, at embedded base of pseudobrachium 364, at external base 420; length of fin (including elbow) 220; length of longest ray 116; interval between pectoral bases 409. Length to origin of pelvic 750; length of longest ray 114; anteroposterior extent of base 91; interval between bases, at anterior border 136, at posterior border 148. Length to vent 750. Head, to end of operculum 443, to gill opening 477. Eye 54. Interorbital 116. Snout, from most advanced point (chin) 125, from tip of upper jaw 80. Depth (in parentheses width) at front of eyes 341 (250), back of eyes 386 (273), pelvic origin 420 (341), vent 386 (182); maximum 451 (354); caudal peduncle 134.

General observations. Though the present specimen exhibits some differences when compared with the original account and figure of *Echinophryne crassispina*, it appears to be satisfactorily referable to this species. Accordingly, no full description is here provided, the points noted either complementing the original account or representing some variation from it (where appropriate, original data are cited in parentheses). Depth 2.2 (1.7) in *Ls*; head 2.3 (2.6-2.9) in *Ls*; eye in snout, from tip of upper jaw 1.46, full 2.29 (1.2-1.5); first dorsal spine 2.75 (7) in head [7', but figure suggests 2.5-3.0; later 'about as long as the distance between the snout and the hinder border of the eye', i.e. from figure, 2-3 in head: is 7 in *Ls* intended?], laid back, reaches more than halfway up second spine. 'Nostrils superolateral, the anterior with a low skinny margin' — the only narial element identifiable in our specimen is a depressed flat longitudinally elliptical yellowish membrane about midway between snout tip and eye, at level of upper half of latter; it has a slightly elevated fleshy rim: internarial distance about half interorbital. There is a well developed palatal frenum. Teeth in the jaws confined to the anterior two-thirds of jaw, mostly uniserial in upper jaw, in at least three rows in front of lower jaw. Orbit surmounted by spines tending to form groups of 2-3. A local concavity below, and largely externad of, the eye. Gill opening small, immediately below outer border of base of pseudobrachium.

Apart from variations in proportions noted above, the chief differences exhibited by the Tasmanian fish are the following. Maxilla barely reaching to front (posterior) margin of eye. It is noted of the first dorsal spine that 'only the extreme tip is fleshy'. Here the spine (slender, spinulose throughout), after narrowingly slightly and briefly near its distal one-fifth, expands somewhat to an ovoid termination beset with a score or so spinules, slender, erect, pungent, noticeably larger than those immediately preceding them and many times more massive than most in the proximal part of the fin spine. The presence of spinules differentiates this species from *E. glauerti* Whitley, 1944; *cf.* Schultz (1966, p.140). The nature of the terminal portion of the first dorsal spine has been accorded taxonomic significance (generic diagnosis of *Echinophryne*, spine 'terminated by a minute fleshy process'): the matter would seem to call for further investigation. The general appearance of the fins is here very

different from that presented in McCulloch & Waite's figure, in which the rays are clearly evident throughout their length: in our specimen the dorsal, anal and caudal rays are enveloped in thick, opaque, abundantly spinose skin to within a millimetre, or less, of the tip; beyond the sheath they project, still enveloped in spinose membrane, as short triangles, a feature shown in the figure in the dorsal (triangles less conspicuous), but not indicated at all in the anal or the caudal. The dorsal terminates in advance of (slightly behind) anal termination: the fin is much lower here, length of longest ray about equal to (approaching twice) combined eye and snout. The anal is much more pointed, rays in the posterior half of the fin decidedly longer than (subequal to) those in the anterior half. The second dorsal spine is more slender. The region between the bases of the second and third dorsal spines, figured as mounded, is strongly excavate.

Coloration. Body dark (on left side chestnut, on right dark brown) above a line from upper angle of operculum to just above pectoral base; elsewhere mostly (on ventral surface wholly) whitish: none of the six white patches reported by Waite & Hale are evident. Head with upper half mostly dark brown (left) or chestnut with a yellow patch behind eye; lower half of lateral surface yellow; ventral surface white, in places faintly yellowish. Dorsal spines pale brownish; soft dorsal greyish or brownish in proximal four-fifths, rest pale yellow. Anal mostly very pale yellow, with some proximal duskiness. Pectoral chiefly pale yellow; a small dark smudge at tip of each ray. Pelvic concolorous with ventral surface. Caudal pale yellow. Inside of mouth, including frenum, white; small rounded red-brown spots along whole length of upper jaw; lower jaw yellowish below; somewhat dusky along its oral border.

Location of fins. The location of the insertion of the fins along the anteroposterior axis of the fish is a function of an arbitrary set of integers of increasing magnitude, being specified by $L = bN^k$, where L = length to fin origin and N = an appropriate natural number. Log lengths to origin of {first dorsal (first spine), pelvic, pectoral (embedded anterior end of pseudobrachium), second (soft) dorsal, anal, caudal} yield a statistically significant straight line when plotted against logs {1,2,4,5,8,10}, the regression equation (L in mm) being $\log L = 1.1363 \log N + 0.5068$. The fit is very satisfactory; $t = 210.333$***. Measured (predicted) lengths are 3.2 (3.2), 7.0 (7.1), 16.0 (16.5), 20.0 (20.0), 33.5 (34.1), 44.0 (44.0).

Head and trunk in plan. As in some other antennariids the greater part of the ventral surface is not far from plane. The head and body together form a nearly complete ovoid, followed by the rapidly narrowing tail. The outline has been traced, discounting the partial interruption to the general outline occasioned by the pectoral bases, and 10 measurements have been made at equal intervals between vent and snout tip; these are found to be very satisfactorily fitted by a fourth degree polynomial (R 0.9985). With W = width as permillage of length to vent and N = serial number of dimension, counting cephalad, the equation is $W = -18.57 + 230.22\,N - 33.4460\,N^2 + 2.17485\,N^3 - 0.083031\,N^4$. Observed (in parentheses estimated) widths are 180 (181), 326 (324), 420 (423), 486 (485), 517 (516), 523 (521), 497 (501), 457 (456), 386 (385), 283 (284); percentage discrepancy between given and calculated values 0.1-0.8, $\bar{x}$ 0.4. The third degree equation, with R 0.9979, is $W = 9.93 + 193.68\,N - 20.0779\,N^2 + 0.348158\,N^3$.

Family CARAPIDAE

Though Fierasferidae is favoured by some authors, e.g., Boulenger (1910), Berg (1940), the name Carapidae is now in general use among both Australian and overseas writers. In earlier texts, e.g., Johnston (1883, 1891), Macleay (1882a), species now referred to the present family were included (along with, among Australian genera, *Genypterus*) in Ophidiidae. Two species, *Carapus homei* (Richardson, 1846) and *Carapus rendahli* Whitley, 1941, have been reported from Tasmanian waters: these records, however, may be regarded as doubtful (see below).

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Members of this family, known vernacularly as Messmate Fish or Pearlfish, are small forms, found usually in littoral waters, particularly around coral reefs, where they live mostly in sponges, in ascidians, in the mantle cavities of molluscs, and in the intestines of asteroids and holothurians, entering the cavity of the host tail first. The relation appears to be one of messmateism, rather than commensalism, the fish emerging at night to feed on crustacea. The planktonic young, which are said to float upside down, possess a long dorsal filament, and have the coils of the intestine outside the body.

KEY TO CARAPIDAE REPORTED FROM TASMANIAN WATERS

1. Vent in advance of pectoral base, Interorbital somewhat convex. Predorsal length > 1.5 (1.7-1.9) head length behind snout tip. Head < 8.5 (6-7.5) in total length. Depth < 16 (9-14) in total length. Vomer with 1-4 centrally placed canines .....*Carapus homei*

2. Vent behind pectoral base. Interorbital flat or concave, with median ridge. Predorsal length < 1.5 (1.1-1.2) head length behind snout tip. Head > 8.5 (10-11) in total length. Depth > 16 (18.5-19.5) in total length. Vomer without canines.....*Carapus rendhali*

Genus *CARAPUS* Rafinesque, 1810

Carapus Rafinesque, 1810, INDICE D'ITTIOLOGIA SICILIANA..., pp.37,57. Type-species, fixed by Intern. Comm. Zool. Nomencl., *Gymnotus acus* Linné. Not *Carapo* Oken = *Carapus* Cuvier, 1816, nor *Carapeus* Valenciennes, 1847, different genera of fishes.
Fierasfer Oken, 1817, *Isis*, p.1 182a. *Nom. nud., ex* Cuvier vernac. ('Les Fierasfers').
Fierasfers Costa, 1834. CENNI ZOOL., p.46. Type-species, *Gymnotus acus* Gmelin.
Oxybeles Richardson, 1846, ZOOL. VOY. EREBUS AND TERROR, FISH., p.73. Type-species, *Oxybeles Homei* Richardson.
? Jordanicus Gilbert, 1905, *Bull. U.S. Fish. Comm.*, 23(2) (1903), p.659. Type-species, *Fierasfer umbratilis* Jordan & Evermann.
Echiodon Thompson, 1837, *Proc. Zool. Soc. Lond.*, 5, p.55. Type-species, *Echiodon drummondii* Thompson. *Partim = Echiodon rendahli* (Whitley, 1941).
? Onuxodon Smith, 1955, *Ann. Mag. Nat. Hist.*, ser. 12, 8, pp. 403-404. Type-species, *Carapus parvibrachium* Fowler.

Carapus homei (Richardson, 1846)

Oxybeles Homei Richardson 1846, ZOOL. VOY. EREBUS AND TERROR, FISH., p.74, pl.44, figs 7-18. Type locality: Timor.
Fierasfer Homei: Macleay, 1882, *Proc. Linn. Soc. N.S.W.*, 6(1), p.120.
? Fierasfer Homei: Johnston, 1883, *Pap. Proc. R. Soc. Tasm.*, (1882), p.127; *ibid.*, 1891 (1890), p.35 - Tasmanian record.
Carapus homei: McCulloch, 1929, *Aust. Mus. Mem.* 5(3), p.359: de Beaufort & Chapman, 1951, FISH. INDO-AUST. ARCHIPELAGO, 9, p.450 (synonymy).
Oxybeles Brandesii Bleeker, 1851, *Nat. Tijdschr. Nederl. Ind.*, 1, p.278. Type locality: Banda, East Indies.

Tasmanian status. In the first published list of Tasmanian fishes (Johnston 1883) the present species is included on the evidence of the manuscript list of Morton Allport on which Johnston's catalogue is based. Johnston observes 'Rare. I have not seen any specimens': he cites (in accordance with his regular practice) the catalogues of Günther (1862) and Macleay (1882b), and notes 'Tasm. (Rich.)'. This raises the matter of the type locality, about which there is some apparent confusion. Of the four specimens listed in the British Museum catalogue (Günther 1862, p.382), one, d, half-grown, is recorded as being from the Feejee Islands (Herald), two, b-c, from Amboyna,

while the entry for a reads, 'Adult. Tasmania. Presented by Sir John Richardson — Type of the species'. However, Richardson's account of his *Oxybeles Homei* (1846, p.75) has 'Hab. Seas of Australia? and Timor'. Macleay's Australian catalogue, cited by Johnston (species 774) makes no mention of Tasmania, giving the (Australian) distribution as 'Torres Straits (Chevert Exp)'. The species appears, without comment, in Johnston's second catalogue (1891). Of possible explanations of the confusion the simplest would appear to be that the entry 'Tasmania' in the British Museum catalogue is an error (? slip for Timor). de Beaufort & Chapman (1951 p.452), who list some two score widely spread localities (e.g., Borneo, New Guinea, Madagascar, Philippines, Ceylon, Hawaii, Fiji), include Tasmania; however, they indicate this is not a locality from which they have examined examples, and it is probable their entry is based on the British Museum attribution.

Johnston's (or, rather, apparently, Allport's) record has been regarded by later writers as suspect. Tasmania is not included in the distribution in the Check-list (McCulloch, 1929), and the species was dropped earlier, without comment, from local lists (Lord 1923, 1927, Lord & Scott 1924). While *Carapus homei* is known to occur - together with *C. hoult*i (Ogilby, 1922) — in Queensland, there appear to be no reliable records of it in any other Australian State: *C. margaritiferae* (Rendahl, 1921), with type-locality north-western Australia, extending to New Guinea (Munro 1967) and to the Indo-Australian Archipelago (de Beaufort & Chapman, 1951), appears to be confined in Australia to the west of the continent. Thus, apart from entries in Johnston's catalogues, the only species of *Carapus* reported from our region - provisionally, on the basis of larval specimens, by Whitley (1941), and definitively on the evidence of the adult or subadult example noted below — is *C. rendhali*, Whitley, 1941. It is suggested it is probable Allport's reference is to that species, and hence *C. homei* (Richardson, 1846) has (as earlier local writers have concluded, though on somewhat different grounds) no satisfactory status in respect of the Tasmanian faunal list.

Carapus rendahli Whitley, 1941

Fierasfer sp. Rendahl, 1925, *Vidensk. Medd. Dansk. Nat. Foren.*, 81, p.13. Type locality: From surface at 36°S, 150°20' E *(Endeavour)*, New South Wales.

Carapus sp. Whitley, 1934, FISH. AND FISHLIKE ANIM. N.S.W. (McCulloch), ed. 3, suppl. Type locality: off Green Cape, New South Wales.

Carapus rendahli Whitley, 1941, *Aust. Zool.* 10(1), p.40, fig. 27. Type locality: Port Jackson, New South Wales.

Echiodon rendahli: Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89(1), p.54; 1968, *Aust. Zool.* 15(1), p.82.

? Carapus rendahli Whitley, 1941, *Aust. Zool.*, 10(1), p.41; larval specimens 'provisionally identified' as this species, netted by the C.S.I.R. vessel *Wareen* at six stations in the Tasman Sea, five off New South Wales, one (station 284/39, 42°15' S, 148°38' E) off eastern Tasmania.

? Fierasfer Homei: Johnston, 1883, *Pap. Proc. R. Soc. Tasm.*, (1882), p.127; *ibid.*, 1890 (1889), p.35. Not *Oxybeles* (= Fierasfer) *Homei* Richardson, 1846.

Tasmanian status. The type locality of *Carapus rendahli* is Port Jackson, New South Wales, the species being based on a specimen of total length 193 (but end of tail truncately broken off), purchased by the Australian Museum in 1889 (Aust. Mus. Regd. no. 1 2 411). At the conclusion of his account of this specimen Whitley (1941) mentions also two specimens trawled by the *Endeavour* off Tuross River, N.S.W., in 1914, one specimen from Green Cape, N.S.W. and 'many small examples in various stages of metamorphosis' netted by the C.S.I.R. vessel *Wareen* in 1939-39. Of the six stations at which material was obtained, five are in the Tasman Sea off N.S.W. (at 30°-36°S, 150°-153°E) and one station 284/39) off eastern Tasmania — the position recorded (42° 15' S, 148°38' E) would locate the point of collection round about 25 km east of the lower half of Freycinet Peninsula. This record provides the only association known

to date of *C. rendahli* with Tasmania (and no great reliance can of course be placed on a provisional specific determination of larval material). An adult or subadult example is here reported from a locality some 130-150 km northward of the *Wareen* station.

Carapus rendahli appears in the New Zealand Check-list (Whitley 1968), the entry being based on *Fierasfer sp.* Rendahl, 1925, and being referred to the genus *Echiodon* Thompson, 1837. In the course of a note on Rendahl's fish (obtained by Dr Mortensen from shepherds, who found it on the shore of Perseverance Harbour) Whitley notes that in his catalogue Günther (1862) wrongly listed New Zealand (error for New Ireland) under the genus *Fierasfer (Carapus)*.

Present material. A specimen *Lt* 125, was taken at Eddystone, near the north-eastern corner of Tasmania, in 32 fathoms (60 m) by Mr Shane Downe on 10 July 1977 (Q.V.M. Reg. No. 1977/5/32). There has been some loss of tissue from the postorbital portion of the head, and the left pectoral is missing (result of maceration?).

Dimensions and proportions. Where proportions for the holotype, total length 93 mm, imperfect near tip of tail, are given or are calculable from measurements recorded these are here shown in square brackets. Some variates in total length (125): head (12.5 mm) 10 [8.4]; depth, maximum for head (6.4) 19.5 [18.5], maximum for trunk (6.1) 20.5; maximum for tail (5.4) 23.1; length to middle of vent (16.5) 7.6, to dorsal origin (15) 8.3 [7.8], to pectoral origin (13.3) 9.4, to anal origin (19.5) 6.4. Some variates in length of head (12.5): eye (2.9) 4.3 [2.8], snout (2.0) 6.3 [4.2], interorbital (1.6) 7.8 [8.4], greatest width of head (4.9) 2.6 [2.1], length of upper jaw (7.5) 1.7 [≥ 1.4], length of pectoral (4.1) 3.0 [3.4]; depth at front of eyes (3.8) 3.3, at back of eyes (5.2) 2.4, at operculum (6.1) 2.0, at middle of length of tail (4.8) 2.6; width at same points (3.1) 4.0, (3.6) 3.5 (4.3) 2.9, (1.5) 8.3.

Other Features. Body compressed, tapering, stiletto-like, becoming highly attenuate posteriorly, the last half-head length or so almost filamentous; not gibbous, dorsal profile not noticeably more arched than ventral. Head moderate; compressed, but thicker than body. Snout broad, bluntly pointed; dorsal profile immediately above mouth subvertical (slightly proconvex) to about level of middle of height of orbit, behind this overall gently convex, the curve less pronounced backward from about level of preopercular border; lower profile much the same as general dorsal sweep in reverse. Mouth terminal, cleft somewhat oblique, at front just below level of lower border of orbit, sloping back and down, at rather less than 10°, extending beyond eye by about two-thirds eye diameter. Upper jaw the longer, lower received within it. Whole extent of upper margin of gape provided by the long slender non-protractile premaxilla; maxilla slender, extending shortly past angle of gape, broadening backward, rounded terminally. Eye large, about one and a half snout, approximately equidistant from gape and dorsal profile. Interorbital narrow, a little more than half eye, bounded by high supraorbital ridges and divided by a median ridge (see below), between ridges convex anteroposteriorly concave transversely. Lower jaw with fleshy lip, not hidden under skin; lips united at symphysis by broad fleshy fold.

The account of the holotype describes the snout as 'with bony crests', but provides no details of a complex system of cephalic crests and ridges, particularly well developed on the snout where it accounts for something like one-third of the total lateral and dorsal preorbital area, but extending also on to the postrostral head. The chief elements are: (a) a high ocular crest embracing the eye above from 2 o'clock (left side viewed), where its effective termination is marked by its junction with two other ridges, to about 10 o'clock, where it makes contact with the anteroposterior angle of the (much inflated) preopercular region, below which point it begins to lose height rapidly, but remains traceable downwards and forwards almost to 6 o'clock; (b) just above upper lip a small subrectangular area, its borders elevated; (c) above (b) and contiguous with it a smaller trapezium, widest anteriorly; (d) from

midpoint of hind border of (c) a median ridge running back to near middle of antero-posterior extension of eye, where it divaricates briefly to embrace a minute forwardly directed median spur from the anterior border of the brain, visible as an opaque mainly whitish, partly yellowish mass through the cranial wall (subelliptical, its length, which is about twice its width, somewhat exceeding an eye diameter, its minor axis occupying half width of dorsum at that level; no obvious division into regions); (e) a very fine median ridge traversing most of region through which brain is apparent; (f) immediately behind brain a ypsiliform system, paired elements anterior, unpaired obscurely traceable back almost to end of head, lapsing to extinction a little in advance of the minute point indicating the site of the remarkable dorsal spine developed in the larval stage and later lost; (g) two strong rather blunt crests (showing some signs of developing two subparallel ridges) arising from near middle of sides of (b), running out and back to meet orbital ridge, (a), at its effective anterior termination; (h) from posterior angles of (c) short paired forwardly convex areas to orbital crest briefly in advance of its junction with (g), both these points wholly on the dorsal surface; (i) from point of junction of (a) and (g) a high straight double ridge running obliquely down and forward on side of head about to level of lower border of pupil (this is fully continuous with the main ocular crest, and could be interpreted as being a direct continuation of it; however, its course represents a marked change of direction, and this, in conjunction with its difference in general character, suggests it may conveniently be regarded as a distinct element); (j) an obscure ridge running down and forward from (i) at its lower end: (k) a ridge down and somewhat back from anterior end of (g) subparallel with (i), almost making contact with (h) at its lower end. In several places the ridge pattern is such as to result in the demarcation of four-sided or somewhat rounded regions.

In the upper jaw the teeth form a villiform band, widest in its middle half or more, where there are some 5-6 rows, but not varying greatly in width throughout most of its length: outermost teeth somewhat larger than rest, subulate, closely set, visible from the exterior along whole length of premaxilla in a row of about three score; in the front of the jaw two pairs of relatively enormous teeth curve right down over the external surface of lower jaw; they can readily be traced into the upper jaw for a distance subequal to their exposed length; their total length, about 0.7 mm, subequal to interval between the pairs. Teeth in the lower jaw in villiform bands similar to those in upper jaw: in front on each side a pair of very large canines, inner larger, straighter than those of upper jaw and inserted just outside them, a small medial point (fleshy?) between the two inner. Palatine with a narrow band of villiform teeth somewhat larger than those in jaws. Vomerine teeth in a low broad mound, somewhat coarser than those in jaws, larger near the middle, but none distinctly caniniform.

Skin smooth. Branchiostegals probably 7 (region damaged). Gill openings wide, extending forward nearly to level of eye, united across isthmus. Lateral line originating on dorsum at upper angle of preoperculum, dipping down quickly to straighten out immediately behind vent, where its distance from ventral profile is 1.3 that from dorsal profile; thereafter continuous to tip of tail, its later portion virtually equidistant from upper and lower borders of body. Its nature is difficult to determine; anteriorly it appears to be nothing more than a simple groove, while in the last quarter of its length, where the shrunken condition of the fish makes it possible to recognize the outlines of the vertebrae, there are indications of its being divided into short linear segments by rather stout transverse septa, but these structures may be adventitious. Vent an elliptical aperture, its major (anteroposterior) axis 1.3 eye; anterior border behind anterior insertion of pectoral by twice oblique width of pectoral base; adpressed pectoral reaching back to about one-fourth of vent; whole opening filled by slightly exserted intestine, pale yellowish with some black peripherally (in the larval stage the intestine is evident in the form of extrasomatic loops).

The dorsal appears to originate about an eye diameter behind head, the anal begins shortly behind the vent; both continuing back uninterrupted to meet in an acute point at tip of tail there thus being no caudal fin. It is difficult to obtain a clear idea of their vertical extent, the finrays being either missing or so closely adherent to the skin as to be almost impossible to tease out (*cf.* Richardson's figures of the types of *C. homei*). An anal ray in the last one-fourth of the length of the fin is 4.7 mm,or 1.6 eye diameter, in length, a dorsal ray in the same region 3.0. Rays unbranched, tapering, flexible. Only right pectoral present; base slightly oblique downward and backward, a little closer to dorsal than to ventral profile; fin slender, pointed, its length 1.4 eye; 15 rays can be counted, but it is possible some may be missing.

Coloration. After preservation in alcohol, head and first one-sixth or so of body whitish (preoperculum dead white), thereafter becoming increasingly tinged with yellowish, color deepening in about last one-seventh to dark brownish. Brain, visible through cranial wall, mainly whitish, partly yellowish; an arc embracing hind border of brain and extending forward laterally for about half the length punctulated with minute melanophores, most densely set posteriorly; a few scattered melanophores in advance of this. Some melanophores on inner surface of posterior half of dorsal portion of orbital crest; continued around most of hind border of orbit. Along bases of both dorsal and anal over the last 60 or so vertebrae (representing a length of some 35 mm) a line of well-defined black dots. All fins whitish.

Discussion. Whitley (1941, p.42) has drawn attention to some differences between his species and its Australian congeners. His remarks are here noted, and subjected to some quantification and to some extension.

Carapus houlti (Ogilby, 1922); type locality off Double Island Point, South Queensland; distribution (McCulloch, 1929), Queensland. *C. rendahli* differs 'in being much more slender and in having different proportions in the parts of the head, also in having canine teeth'. Whitley's species has depth in total length 18.5-19.5; *cf.* 8.5-9.7; dorsal profile not arched, *cf.* strongly gibbous (hence Ogilby's suggested vernacular name, Hump-backed Messmate); eye in holotype, 2.8 in head, noticeably larger, but not so in Tasmanian specimen, 4.3, *cf.* 4.5-5; vomer without distinct canines, *cf.* 'with four strong, close-set caninoid teeth, situated one behind the other, the third from the front the largest'; head thicker, *cf.* thinner, than body.

Carapus margaritiferae (Rendahl, 1921); type locality, Cape Jaubert, North-western Australia; distribution (McCulloch, 1929), North-western Australia (and extralimital, including coast of Flores, Saleyer) (referred by Munro (1967) to *Onuxodon* Smith, 1955). Resembles *C. rendahli* in having 'similar dentition' (= broadly similar), but 'differs in proportions of head and body and has longer pectoral fins'. Present species has depth in total length 18.5-19.5; *cf.* 9.4-11.6; interorbital concave with median ridge, *cf.* convex; greatest width in greatest height 1.3 (Tasmanian specimen), *cf.* 2.2-3.4; pectoral 3.0-3.4 in head, *cf.* 1.7-2.

Carapus homei (Richardson, 1846); type locality, Timor (see remarks above on British Museum entry, Tasmania), distribution (McCulloch, 1929), Queensland, East Indies, Western Pacific (extralimital distribution very wide; includes, e.g., New Guinea, Madagascar, Philippines, Ceylon). Differs from *C. rendahli* in having 'enlarged teeth on vomer and jaws quite unlike my species' (in *C. rendahli* no caniniform teeth on vomer; in *C. homei* 1-4 centrally placed canines, which may be more or less coalescent, flanked or ringed with smaller teeth: in upper and lower jaws in *C. rendhali* on each side one (type-specimen) or two (Tasmanian example) fang-like teeth near symphysis; in *C. homei* one or two small canine-like teeth in upper jaw near symphysis, teeth in lower jaw larger than those in upper, some lateral ones enlarged ; depth in total length 18.5-19.5, *cf.* 8.5-14; head in total length 8.5-11.1, *cf.* 6-8; vent

behind, *cf.* before, pectoral base; interorbital concave with median ridge, *cf.* convex; pectoral 3.0-3.4 in head, *cf.* 1.5-2.2.

Data here cited additional to information set out by Whitley are derived from the following sources, ranges being a conflation of values there given: *C. rendhali*, original description (Whitley, 1941), present specimen; *C. houlti*, original description (Ogilby, 1922); *C. margaritiferae* de Beaufort & Chapman (1951), Munro (1967); *C. homei*, original description (Richardson, 1846), de Beaufort & Chapman (1951), Schultz (1960), Munro (1967).

C. rendahli would thus appear to be a tolerably distinct species, having as its nearest ally *C. margaratiferae*, while being trenchantly separated from *C. homei* and *C. houlti* by their having vent behind pectoral base and lacking canine teeth. From all Australian species it is distinguished by its markedly more slender body. From the Indo-Australian Archipelago *C. gracilis* (Bleeker, 1856) it differs in having the maxilla not hidden by skin (*cf.* hidden), also in having the lower lip developed, with the lips united anteriorly by a wide transverse band — the opposite features characterizing the genus *Jordanicus* Gilbert, 1905, in which Bleeker's species is placed by Munro, being referred, however, to *Carapus* by Weber & de Beaufort. From the imperfectly known *Oxybeles lumbricoides* Bleeker, 1854 (type locality, near Ceram), for which Gill created a new genus, *Helminthoides*, 1864 (preoccupied = *Pirellinus* Whitley, 1928) it is distinguished by the much greater attenuation of the latter (depth > 40, head about 21 in, imperfect, total length), and by the end of the maxilla being under (instead of well behind) eye.

Mr Downe's Tasmanian fish seems clearly referrable to *C. rendahli*, its characters being in good overall agreement with those reported for the holotype; the chief departures from these being the smaller eye (4.3, *cf.* 2.8, in head) and the shorter snout (6.3, *cf.* 4.2, in head) of the present specimen.

Family PLESIOPIDAE

Of the ten species of Plesiopidae, representing four genera, in the Australian Check-list (McCulloch 1929), one only is credited to Tasmania, namely, *Trachinops caudimaculatus* McCoy, 1890, of which *Pseudochromis rodwayi* Johnston, 1902 is treated as a synonym. It is not evident, at this distance in time, whether the attribution to Tasmania of McCoy's species (otherwise known only from Victoria) was based on observed material or simply on Johnston's paper. The relevant local catalogues (Lord 1923, 1927, Lord & Scott 1924) list only McCoy's species (second binomen consistently misspelt *caudomaculatus*). In a recent review of the genus *Trachinops*, Allen (1977) has reported *T. caudimaculatus* from Tasmania, basing his account on eight examples from Oyster Cove, east coast; however, these specimens appear to be referable to another species here described.

Examples of a *Trachinops* from our north-west coast that differ in several features from the members of the genus generally recognized are here regarded as representing another species. As Johnston's 1902 name would appear to be available, it has been deemed expeditient (though with some reservations — see below) to refer them to his *Pseudochromis rodwayi*. The Oyster Cove specimens reported on by Allen are found to exhibit the characteristic features of the north-west coast fish, and are here treated as conspecific with them. There thus exists at present some uncertainty as to whether one or two species of *Trachinops* occur in our waters.

In the subjoined key entries for *Trachinops caudimaculatus* are based on the original description of the species, not on examined material.

E.O.G. Scott

KEY TO PLESIOPIDAE RECORDED FROM TASMANIA

1. Caudal fin lanceolate; behind greatest width, at ≤ 0.5 total length of fin, extending as a pennon, tip of which may be produced as a filament; middle rays longer than head, < 4 in standard length. Patch of small predorsal scales delimited by proconcave arc across head, short oblique segment of superior lateral line and a subhorizal segment intercalated between these above operculum. Teeth in lower jaw uniserial throughout; palatine teeth biserial throughout. Greatest depth of anal fin behind middle of fin length...*Trachinops caudimaculatus*

2. Caudal fin cuneiform, behind greatest width, at ≥ 0.5 (*ca* 0.8) total length of fin, ending almost at once in a subvertical border, with short median spur; middle rays shorter than head, > 4 in standard length. Patch of small predorsal scales wholly delimited by proconcave arc across head and short oblique segment of superior lateral line. Teeth in lower jaw briefly biserial (or triserial) anteriorly; palatine teeth biserial anteriorly, uniserial posteriorly. Greatest depth of anal fin at, or in advance of, middle of fin length.....*Trachinops rodwayi*

Genus *TRACHINOPS* Günther, 1861

Trachinops Günther, 1861, CAT. FISH. BRIT. MUS., 3, p. 366. Type-species, *Trachinops taeniatus* Günther, 1861.

Trachinops rodwayi (Johnston, 1902)
(fig. 2)

Pseudochromis rodwayi Johnston, 1902, *Abstr. Proc. R. Soc. Tasm.*, April 29, p.vi. Type locality: 'in or near' Macquarie Harbour, Tasmania [in Check-list (McCulloch, 1929, p. 166), in error, George's Bay - now known as George Bay; east coast.] McCulloch (1929, p.166) states 'name published slightly earlier in a newspaper, probably "Hobart Mercury"'.

? *Trachinops caudomaculatus* [*sic*]: Lord, 1923, *Pap. Proc. R. Soc. Tasm.* (1922), p.67; and 1927, *J. Pan-Pac. Res. Inst.*, 2(4), p. 14: Lord & Scott, 1924, SYNOP. VERT. ANIM. TASM., pp. 10, 55 (in synonymy, *Pseudorhombus rodwayi* Johnston, *Pseudorhombus lapsus calami pro Pseudochromis*). Not *Trachinops caudimaculatus* McCoy, 1890.

Trachinops caudimaculatus: McCulloch, 1929, *Aust. Mus. Mem.*, 5(2), p. 166; *partim*, *Pseudochromis rodwayi* Johnston, 1902.

Trachinops caudimaculatus: Allen, 1977, *Rec. W. Aust. Mus.*, 5(1), p. 68; eight specimens from Oyster Cove, Tasmania; not semidiagrammatic fig. 1c.

Material. Specimens (a), (b), (c), (d), *Ls* 48.5, 55.5, 55.0, 58.0 mm, Wynyard, north-west coast, Tasmania, H.J. Griffith, 8 April 1974 (Q.V.M. Reg. No. 1974/5/120); (e), *Ls* 53.5, Boat Harbour, north-west coast, N.W. Coast Scuba Club, 17 March 1974 (Reg. No. 1974/5/124); (f), (g), *Ls* 58.0, 61.0, same origin as (e), but kept alive for some time in an aquarium, and registered separately (Reg. No. 1974/5/125). The present account is based on these specimens.

Through the courtesy of Mr A.P. Andrews, Curator of Fishes, the Tasmanian Museum, Hobart, and Dr J.R. Paxton, Curator of Fishes, the Australian Museum, Sydney, plesiopod material from their institutions has been made available for examination. The Tasmanian Museum material comprises seven series, totalling 15 fish, all from localities in the south of the State. It had been hoped this might yield decisive evidence

FIG. 2. - *Trachinops rodwayi* (Johnston, 1902). A specimen, standard length 58.0 mm, total length 73.5 mm, caught at Boat Harbour, north-west coast, Tasmania, 17 March 1974, by the North-West Coast Scuba Club; Queen Victoria Museum Reg. No. 1974/5/185. Lateral aspect, x 1½.

of the occurrence in Tasmania of *T. caudimaculatus;* though all the examples are so labelled, and though some of them may indeed be this species, unfortunately the imperfection of the distal border of the caudal fins is such as to preclude a definitive determination. The Australian Museum material comprising six of the eight individuals from Oyster Cove (Regd. No. I.17549-006; coll. D. Hoese & W. Ivantsoff, 1 Dec. 1972), labelled *Trachinops caudimaculatus,* and providing the basis for Allen's account of that species (type, from Williamstown, Hobson's Bay, Victoria, not examined) prove to be referable to *T. rodwayi.*

Meristic characters. Considerable individual variation is encountered: in the circumstances the seven specimens on which the description is based are reported separately. Br. 6. D. XV, 18; XV,18; XV,18; XV,17; XV,16; XV,17; XV,16. A. III,13; III,18; III,15; III,18; III,17; III,18; II,16 (in (g) only two anal spines developed, what would apparently have been the first being replaced by a small fleshy flap). P. (left/right) 16/17; 17/16; 17/16; 17/17; 16/16; 16/17; 17/17; 17/19. V. I,4 (all specimens). C.18 (15 branched) + 7/8 dorsal/ventral minor, procurrent rays; 18(14) + 8/7; 18(14) + 7/6; 20(15) + 6/6; 19(15) + 7/5; 20(-) + 6/6; 19(-) + 7/5: 13 rays fully reaching hind border. Upper lateral line, left, 6 ascending obliquely to near dorsal profile + 45 bordering profile/right 6 + 48; 6 + 44/5+44; 6 + ?43/6+43; 6 + 43/6+43; 6 + 41/5+44; 6 + 44/7+43; 7 + 49/7+49. Scales in longitudinal series 46; 44, 45; 46; 43; 42, plus in all cases about 4-6 on caudal base (and in some individuals additional scales, small, extending for a variable distance up rays). About 15 scales counted obliquely behind pectoral base. Gill rakers on anterior arch, specimen (g), 8 + 20.

The following counts are given by Allen (1977, p. 68, and tables 1, 2, p. 70) for the eight Australian Museum specimens, of which he observes they are 'essentially identical to McCoy's fish' - they are indeed quite similar, but are found to exhibit the characteristic differences set out in the key above. D. XIV (6 specimens), XV(2), 16 (3), 17 (5). A. III, 17 (1), 18 (4), 19 (3). P. 15 (1), 17 (4), 18 (3). Total rakers on first gill arch 29 (1), 30 (3), 31 (3). Anterior lateral-line scales 45-49 (7), 50-54 (1). Posterior lateral-line scales 13 (3), 15 (1), 16 (2), 17 (1), 18 (1).

Proportions. A set of eighteen dimensions for each specimen, expressed as permillages of standard length, is set out in table 1. Table 1 covers the larger dimensions: twenty-three smaller measurements, of such magnitude that they are conveniently reported in the form dimension-in-head, are exhibited in table 2.

Description. As the relevant data are directly derivable from tables 1 and 2 proportional dimensions customarily included in a general description are not given here.

Elongate, slender, moderately compressed, greatest depth of body modally about one and two-thirds greatest width, occurring shortly behind head, subequal to that of

TABLE 1

Trachinops rodwayi (Johnston, 1902). Large dimensions: first line absolute, standard length, mm; all other lines relative, permillages of standard length. Specimens (a) - (d) Wynyard, north-west Tasmania, (e) - (g) Boat Harbour, north-west Tasmania.

Feature	Specimen (a)	(b)	(c)	(d)	(e)	(f)	(g)
Standard length	48.5	55.5	55.0	58.0	53.5	58.0	61.0
Total length	1235	1207	1209	1267	-	-	1230
Length to origin of first dorsal	285	268	256	262	280	257	272
Base of first dorsal	348	323	327	336	346	283	328
Length to origin of second dorsal	633	611	602	617	645	600	613
Base of second dorsal	212	245	275	245	290	247	280
Length to origin of anal	571	541	527	553	579	552	607
Base of anal	282	288	318	309	355	293	287
Length to vent	495	486	455	490	520	474	549
Length to origin of pectoral, base	229	225	229	226	226	212	213
Length to origin of pectoral, first ray	270	265	255	259	273	262	250
Length of pectoral, total	231	229	242	242	-	212	-
Length of pectoral, longest ray	186	180	182	205	-	179	-
Length to origin of ventral	247	218	227	226	236	207	230
Length of ventral, total	175	173	178	179	-	171	-
Length of head	268	263	255	259	275	260	246
Maximum depth of head	190	177	180	172	204	172	182
Maximum depth of body	190	180	182	172	209	174	166

head; dorsal profile decreasing more or less evenly caudad, ventral profile slightly more convex posteriorly. Snout in lateral view very bluntly rounded, a trifle more pointed in plan. Eye large, at its middle twice, or more, as far from ventral as from dorsal profile, the former distance subequal to pupil. Interorbital moderately convex, the curvature mainly lateral. Orbital rim smooth. Preorbital entire. Anterior nostril a short tube, the posterior part of the free rim higher than the anterior; nearer to border of preorbital than to orbit; internarial rather less than interorbital. Posterior nostril a simple opening, somewhat larger than largest of nearby cephalic pores, situated against orbit on same horizontal level as tubular nostril. Cleft of mouth oblique, opening dorsally, middle of upper lip about on horizontal level of middle of eye, tip of premaxilla almost, at times quite, reaching ventral profile. Maxilla reaching to below 0.5-0.9, modally 0.7, eye, greatest distance of its broadly rounded tip from orbit about half its maximum depth. Upper lip rather narrow, of equal width throughout much of its length, very briefly narrower near the symphysis, very slightly wider in its last one-third. Lower lip widest at about anterior one-third of its length, its width there slightly exceeding that of upper lip; behind this narrowing rapidly to a fine point; in advance of this upper border flattening and continuously approximating lower border, which is still evenly convex, resulting in the formation of a pronounced notch at symphysis. Gill rakers, specimen (g), 8 + 20 on anterior arch, all slender, slightly flattened, of virtually equal width almost to tip, mostly straight, several at base of series briefly curved forward proximally; longest (lowest) on upper limb of arch two-thirds first of upper limb, which is little shorter than longest (middle), which is subequal to longest branchial filament and to eye.

In either side of upper jaw a row of conical teeth, about 8-12 in hind part minute, about 8-12 in front part several times larger; some still larger retrorse teeth on either side of the symphysis, either forming two separate clusters or being contiguous; in the latter case each tooth-line may dip backward, the two lines thus becoming continuous as a proconcave arc, behind which the patch may be more or less

TABLE 2

Trachinops rodwayi (Johnston, 1902). Small dimensions: first line absolute, length of head, mm; all other lines relative, dimension in head. Specimens (a) - (d) Wynyard, north-west Tasmania, (e) - (g) Boat Harbour, north-west Tasmania.

Feature	Specimen (a)	(b)	(c)	(d)	(e)	(f)	(g)
Length of head	13.0	14.6	14.0	15.0	14.7	15.1	15.0
Eye	3.3	3.5	3.5	3.8	3.0	3.1	3.3
Snout	4.5	4.9	4.7	5.0	5.3	5.6	5.4
Interorbital	3.7	3.9	3.6	3.7	3.8	4.1	3.8
Length of longest pectoral ray	1.4	1.5	1.4	1.4	-	1.8	-
Length of ventral spine	3.7	3.7	3.5	3.2	-	3.7	3.1
Length of longest ventral ray	1.8	1.8	1.5	1.6	-	1.9	1.6
Length of first dorsal spine	7.5	7.7	7.0	7.1	7.4	7.9	7.1
Length of median dorsal spine	3.7	3.7	4.5	3.8	3.8	3.1	3.3
Length of last dorsal spine	3.0	2.9	4.0	3.8	3.9	3.1	3.1
Length of first dorsal ray	2.8	2.9	2.9	3.0	2.9	2.8	3.0
Length of last dorsal ray	2.1	2.4	3.3	2.4	2.8	3.0	2.4
Length of first anal ray	3.2	3.0	3.5	2.9	-	2.5	2.1
Length of fourth anal ray	2.4	2.4	2.3	2.5	-	2.2	2.1
Length of last anal ray	4.3	4.8	2.3	2.9	-	3.9	2.7
Length of longest anal ray	2.2	2.3	2.0	2.4	-	2.2	1.9
Caudal, total length	0.94	0.97	0.93	0.86	-	-	-
Caudal, length from base of median ray	1.3	1.3	1.2	1.2	-	-	-
Caudal, oblique length to lateral angle	1.1	1.1	1.1	1.2	-	-	-
Caudal, length of median projection	5.0	12.2	5.8	6.0	-	-	-
Depth at operculum	1.4	1.5	1.4	1.5	1.3	1.5	1.4
Depth at vent	1.4	1.5	1.4	1.5	1.3	1.5	1.5
Depth of caudal peduncle	2.1	2.1	2.3	2.2	2.2	2.5	2.2

rounded or somewhat pointed posteriorly. Teeth in lower jaw in a row quite, or almost, continuous across mandibular symphysis; usually large in front; mostly smaller behind, but with 1-3 enlarged caniniform, sometimes recurved teeth in anterior one-third of jaw, the complement not necessarily the same on the two sides; for some distance on either side of symphysis, around terminal anterior arc of jaw, small teeth in two, or very briefly three, irregular rows. Teeth on palatines small, sometimes becoming moderate anteriorly, uniserial in posterior half or so, biserial anteriorly; subcontinuous with vomerine series. Vomerine teeth somewhat variable, of moderate to large size, in two clusters, sometimes coalescent. Tongue small, bluntly pointed, smooth.

No opercular or preopercular spines. Operculum entire; with flat rounded fleshy angular lobe, its tip reaching to, very briefly short of, or very briefly beyond, level of insertion of uppermost pectoral ray; margin not, or very shallowly, notched immediately beneath lobe. Preoperculum entire; hind margin very slightly oblique downwardly and backwardly, its least distance from orbit 2 to 2.5 times in its greatest distance from opercular border. Preopercular ridge parallel with border, distant from it by about width of upper lip at middle. Gill opening wide; upper end about on horizontal level of upper orbital rim; distant from orbit by about an eye diameter, or by an interval equal to, or a little in excess of, its direct distance from insertion of uppermost pectoral ray. Branchiostegal membranes not united across isthmus; extending forward to within a pupil diameter of lower lip. Lateral line in two sections; anterior originating near upper angle of gill opening, running upward and backward in a straight or slightly sigmoid line to within 1-2 pore lengths of dorsal profile at, or very shortly behind, base of first dorsal spine; continuing back along dorsal base,

one pore length or so below it, modally to below last dorsal ray, at times to one or two pores short of, or beyond, that point; tubules 5-7 + 41-49, modally 43, subrectangular, longer than high, anteriorly sometimes becoming somewhat longer relatively near hind end of series, a small pore at posteroinferior angle of scale or sometimes at end of a downwardly directed tube here: posterior (inferior) portion comprising 16-21 scales (right and left totals may differ), running along middle of flank to caudal origin, or continuing by 1-2 scales on to base of fin; length highly variable, origin ranging from below about middle to below about last one-sixth of total dorsal base; tubules usually somewhat rounded in front, becoming longer, less deep, subrectangular behind, each with a small posteriorly placed rounded aperture. Three complete scales (oblique count) between last scale of upper section of lateral line and scale of lower section below it.

Head with very numerous circular or subcircular pores, roughly classifiable as small and very small. Where these occur in extensive aggregations the number and disposition vary widely between individuals, often, less widely, between two sides of same specimen. More or less constant series include : (a) a pair, widely separated, on dorsum just internad, and slightly in advance, of anterior nostrils (in some individuals a line of 4-8 smaller pores linking, or slightly in advance of, these are detectable); (b) between posterior nostrils a proconcave arc of 4, the outermost partly in front of, almost in contact with, the nostril, the interval between inner and outer about 4 times interval between outer and nostril; (c) behind (b), just before level of middle of pupil, a proconcave arc of 3, the outer about twice as far from median as from orbit; (d) a line of 7-12 between vertical segment of preopercular border and preopercular ridge, often also one or several irregularly disposed pores behind, or, more commonly, in front of, this line; (e) usually 3, evenly spaced, on lower limb of preoperculum; (f) a small group, commonly 2-4, regularly followed by 2 side by side, at mandibular symphysis; behind these constantly 3 in each jaw, evenly spaced, hindmost below expanded end of maxilla, these 3 an extension of arc formed by (e); (g) very variably developed circumocular series, the most regularly detectable about 12-14 between 2 o'clock (left side viewed) down and round very close to orbit to about 8 o'clock, first 3-4 decidedly larger than rest, often about 8 between 8 o'clock and 11 o'clock, several of uppermost larger; rarely a pore close to orbit between 11 o'clock and 2 o'clock; (h) an extensive series of pores at or near the proconvex arc running across dorsum from origins of left and right upper lateral lines that delimits anterior boundary of the conspicuous patch of small predorsal scales; comprising as its primary feature some 15-20 pores, following, with some local irregularities and interruptions, the line of cessation of the scales, in advance of this highly variable, supplemented here by an array of from numerous to very numerous pores, the closer of which may form parts of one or more imperfect arcs more or less following course of main arc, or may scarcely be organized into linear arrangements, with those further forward, numbering from less than a score to upwards of two score, extending along lateral portion of dorsum and upper part of lateral surface in a subtriangular region with apex near posterosuperior angle of orbit; median area of dorsum between these regions and level of series (b) either lacking pores or having 2-3 only.

No scales on interorbital, any part of snout, lower jaw, chin, isthmus. Small obscure largely embedded scales covering most of preoperculum, extending forward beneath orbit over most of upper part here, absent from a strip along inferior border. Moderate sized scales on most of operculum, obscure, embedded, some 4-5 vertical rows, longest (anterior) with about 6-8 scales. A conspicuous predorsal patch of scales, markedly smaller than adjacent scales, one-sixth or less size of large scales of flanks; sharply delimited, in front by a forwardly convex arc extending across nape from upper angle of gill opening on either side, behind, to within a distance equal to one or two pore lengths of insertion of first dorsal fin, by short oblique ascending segments of superior lateral line, either ceasing at dorsal origin or continuing beside the bases of several spines; the junction between these two borders forming a sharp angle (no

intercalated subhorizonal border segment as depicted by M'Coy (1890, pl. 194, fig. 1b) for *Trachinops caudimaculatus*). Pectoral base with embedded scales of moderate size in about 5 downwardly and backwardly oblique rows. A proconcave arc delimits a series of scales continuing from caudal peduncle on to caudal fin, mesial number modally about 5, tending to decrease in size laterally and posteriorly; in some individuals additional scales, small, extending briefly up rays. Dorsal, anal, ventral bases naked.

First dorsal with 14-15 spines, originating above pectoral base, slightly behind level of insertion of uppermost ray, terminating in advance of hypural joint by about combined eye and snout; spines flexible, slender, straight, acute (but with the enveloping integument blunt and tending to be recurved); first spine shortest, lengths increasing for about one-third of base, thereafter remaining subequal or regularly increasing somewhat posteriad. Second dorsal with 16-18 rays; height of fin increasing somewhat posteriad. Second dorsal with 16-18 rays; height of fin increasing to about middle, thereafter much the same; rays in about hind half of fin branched, others simple. First dorsal base longer than second, ratio of lengths, however, decidedly variable, ranging in specimens (b)-(d) from 1.1 to 1.4, mean 1.22 ± 0.0532, but in (a) reaching 1.64. Anal with 3 spines (specimen (2) abnormal, 2 only), 15 (one specimen 13)-18 rays, of which last 4-6 are branched; broadly oval; originating below 2nd-9th last dorsal spine, ending below, or slightly in advance of, last dorsal ray; with fin normally erect lowest point on border occurs at from first one-third to just in advance of middle of length. Pectoral with 16-19, modally 17, rays, uppermost 1-2 lowermost 1-2 simple, rest branched, mesial one for upwards of half length; originating barely in advance of, below, or barely behind top of soft opercular lobe; total length from four-fifths of head to just less than head; when adpressed reaching halfway, or a little more, along first dorsal base; oblique length of base subequal to eye. Ventral with I spine, 4 rays; pointed; two rays adjacent to spine longest, subequal, about twice spine; all rays branched, middle two doubly divided; originating in advance of bases of pectoral rays, length two-thirds that of pectoral, extending about halfway to anal origin. Caudal with 18-20 main rays, 14-15 branched, about half a dozen smaller procurrent accessory rays at base above and below; bluntly cuneiform, width of subvertical hind border twice distance between insertions of uppermost and lowermost ray; at hind border a short mesial triangular spur, involving 3-5 rays; all 13 rays characteristically reaching fully to hind border subequal, except those of median spur; length of middle caudal ray less than (0.8-0.9) head, 4.3-5.0 in standard length.

Coloration. The following brief notes were made on living examples. General color olivaceous above, lightening below midlateral line, whitish below. Considerable difference between darkest and lightest individuals, latter more yellowish above. Indications on flank of one or more specimens of a line of darker markings in the form of rounded cross-hatched patches separated by intervals somewhat greater than their diameter; other examples more or less mottled. First dorsal more or less colorless. Second dorsal pale orange with darker bars, chiefly presented by rays. Caudal orange, deeper at base. Anal from almost colorless to very pale yellow. Pectoral somewhat dusky basally, lighter distally.

In preserved specimens each scale on flank with a central ovoid or diamond-shaped area of numerous midbrown to dark brown chromatophores, surrounded by lighter, so that scale-rows are clearly delimited by oblique lines of whitish, one series running up and forward crossing another series up and backward; for a short distance below dorsal profile pigmentation may be sufficiently extensive to lead to loss of light dividing lines; pigmentation becomes increasingly less extensive and less intense towards ventral profile, becoming absent on all or most of mesial portion of ventral surface of trunk, and in some individuals in a narrow strip along anal base : no major marking discernible on side of body. Upper part of head almost uniform dark brown except for broad, much darker interorbital bar; lower part lighter, pale brown or light grey,

sometimes with small areas of yellowish. Lips very variable, ranging from mostly dark brown to almost wholly whitish. Lower surface whitish or dark grey, several individuals with touches of yellow on isthmus.

Along whole of dorsal base a narrow yellowish line; above this a well marked band of dark brown, of even height throughout whole, or virtually whole, of its extent; typically occupying proximal three-fourths or four-fifths of height of spinous dorsal, at middle of soft about two-fifths; both fins presenting a conspicuous distal band of white. Pectoral with very narrow basal are of brown, otherwise whitish. Anal, ventral wholly white. Caudal white; broad basal patch of dark brown, approaching black; pigment deposited in membrane, forming sharply defined lines, most intense proximally; main region of pigmentation ceasing at about middle of fin, but 3-5 lines usually extending further to reach to, sometimes beyond, last one-fourth of length.

Anal spines. The anal spines exhibit a length-position relationship frequently found among these elements, namely, $L = b\,N^k$, where L = length of spine, N = its serial number, counting caudad. The following are the rectified equations, $\log L = k \log N + \log b$, together with t, and with observed (in parentheses estimated) lengths (mm) for specimens (a)-(f): (g) abnormal, 2 spines only.

(a) Log L = 1.0115 log N + 0.1216; t = 13.256*; 1.3(1.3), 2.8(2.7), 3.9(4.0).
(b) Log L = 1.0267 log N + 0.1161; t = 165.293**; 1.3(1.3), 2.7(2.7), 4.0(4.0).
(c) Log L = 0.7982 log N + 0.2282; t = 38.221*; 1.7(1.7), 2.9(2.9), 4.1(4.0).
(d) Log L = 0.5263 log N + 0.4462; t = 54.346*; 2.8(2.8), 4.0(4.0), 5.0(5.0).
(e) Log L = 0.7934 log N + 0.2762; t = 28.088*; 1.9(1.9), 3.1(3.2), 4.3(4.3).
(f) Log L = 1.0979 log N + 0.0806; t = 77.941**; 1.2(1.2), 2.6(2.6), 4.0(4.0).

Discussion. Johnston's account of his *Pseudochromis rodwayi* has never seen the light of publication in a formal scientific paper, having remained buried in the relative obscurity of the minutes of the Society's meeting of 29 April 1902. It touches on several features critical for the assessment, even at the familial level, of the taxonomic status of his fish, and the reader is referred to it for a description.

The view adopted by Lord, Lord & Scott and McCulloch that this account should be interpreted as referring to *Trachinops caudimaculatus* M'Coy (species name regularly misspelt *caudomaculatus* by Tasmanian authors) was presumably based on two main considerations, first, the general overall agreement in features (for exceptions, see below); secondly, the probable (or, it may well have been, known) occurrence of the Victorian species in Tasmania, and the lack of material of *Pseudochromis rodwayi* other than the holotype; together, perhaps, with the more likely occurrence in our waters of a plesiopid than a pseudochromid. On the weight of the evidence, this identification would seem reasonable; and with its adoption in the literature now a part of history, it is probably expedient it should be accepted. However, attention should be called to three points of discordance — dorsal fin formula, relation of branchiostegal membrane to isthmus, and shape of dorsal and anal. In the Pseudochromidae dorsal spines are notably outnumbered by rays (about II-VII — characteristically III (Greenwood *et al* 1966, fig. on p. 424) — 19-28), whereas in the Plesiopidae rays are about as numerous as, or more numerous than, spines. Hence if Johnston's III, 26-27 is reliable, his clearly expressed conviction that his specimen is a pseudochromid is justified, and, concomitantly a plesiopid attribution is negated. However, against this conclusion it may be contented, first, that Johnston himself characterized the dorsal count as unsatisfactory; secondly, that his total count of 29-30 is in good agreement with 31 noted by M'Coy for *P. caudimaculatus* and with about 30-31 by Allen (1977) for the present species (identified as *P. caudimaculatus*), as well as with 31-33 in our specimens. Though Johnston took no note of the branchiostegal membranes in his specimen, the generic diagnosis of *Pseudochromis*, cited by him, specifies 'gill membranes joined inferiorly': on the other hand, as noted by M'Coy (1890, p.341), following Günther (1861, p.366), in *Trachinops* they are not thus united, and this is the case in our

material (however, M'Coy's illustration, pl. 194, fig. 1f, is in disagreement with his text). Johnston's notation 'dorsal and anal fins produced posteriorly' scarcely seems applicable either to the example of *P. caudimaculatus* as figured by M'Coy or to our material, certainly not in the sense it is, for instance, to the one plesiopid, other than the one *Trachinops*, *T. noarlungae* Glover, 1974, noted from waters adjacent to Tasmania, namely, *Paraplesiops meleagris* (Peters, 1870), recorded from South Australia, in which the fins extend back about to level of end of caudal.

Species of *Trachinops*. To the two species of *Trachinops* Günther, 1861 (a wholly Australian marine genus) appearing in the Check-list, *T. taeniatus* Günther, 1861 (type-species; New South Wales), *T. caudimaculatus* M'Coy, 1890 (Victoria, Tasmania) are now to be added *T. noarlungae* Glover, 1974 (South Australia, Western Australia), *T. brauni* Allen, 1977 (Western Australia), *T. rodwayi* (Johnston, 1902) (Tasmania). The first four species have been keyed by Allen (1977, p.31) in his review of the genus, *T. brauni* being placed in a new subgenus, *Paratrachinops*, characterized chiefly by small number of dorsal spines (10-11, cf. 14-15 in nominate subgenus), larger ventral fins (0.7-1.2, cf. 1.4-2.0 in head), fewer gill rakers on anterior arch (23-24, cf. 26-31).

In general, fin counts in the subgenus *Trachinops* show considerable intraspecific variation, associated with conjoint interspecific classes, obliging the key maker to qualify even ranges with 'usually'. Frequency distributions for fin ray and gill raker counts given by Allen (table 1) exhibit some modal differences, but samples are somewhat small for statistical analysis. Some disjunct distributions are encountered, however, in lateral line scale counts (table 2). One of the most immediately useful criteria for species separation in this genus is the color pattern, a diagram in Allen's paper (fig. 1) serving to differentiate the four species with which he deals.

T. rodwayi may be distinguished from *T. brauni*, *T. taeniatus* and *T. noarlungae* as follows. From *T. brauni* by the subgeneric characters; also by its greater number of posterior lateral line scales (16-25, cf. 3-6), and by color pattern (absence of broad dark band along whole length of side, presence of isolated large dark spot on caudal). From *T. taeniatus*, which has narrow blackish stripe from eye to caudal tip, caudal without basal marking, lanceolate, its middle rays 2.4-3.4 in *Ls*, 0-7 posterior lateral line scales, in having flank plain, caudal cuneiform, with basal marking, its middle rays 4.6-5.0 in *Ls*, posterior lateral line scales 16-20. From *T. noarlungae*, which has caudal plain, its middle rays 2.2-3.1 in *Ls*, anal rays 22-23, anterior lateral line scales 73-90, posterior lateral line scales 9-14, vertical scale rows about 80-85, in having caudal ornamented, its middle rays 4.6-5.0 in *Ls*, anal rays 13-18, anterior lateral line scales 47-56, posterior lateral line scales 16-25, vertical scale rows about 42-46 (plus about 4-6 on caudal base).

T. rodwayi most nearly appraoches *T. caudimaculatus*, which has essentially the same color pattern, and with which it has perhaps been confused. Chief differences (characters of *T. caudimaculatus* in parentheses) : teeth in anterior part of lower jaw briefly biserial, or more briefly triserial (uniserial); palatine teeth biserial, in about anterior half of series, thereafter uniserial (biserial throughout); caudal fin cuneiform (lanceolate), behind level of greatest depth, at about four-fifths (about half) total length, almost at once subvertical with short median spur (produced as pennon, tip of which may be filamentous); patch of small predorsal scales wholly delimited by proconcave arc across head and on each side by short oblique segment of upper lateral line (border with an additional subhorizontal segment intercalated between these above operculum); anal deepest in front of, or at (behind) its middle.

After pointing out that while Günther (1861) in establishing *Trachinops* for *T. taeniatus* gave 'scales cycloid' as a generic character, later Kner (1865) described the scales in this species as being cycloid anteriorly ctenoid posteriorly, M'Coy

observed, "In the present species, I think all the large scales are ctenoid". In our fish while the great majority of the large scales are ctenoid (those at middle of body with spinules more numerous, in three rows, two of which are complete, and much stouter than in M'Coy's figure 1m), in an area on upper part of trunk just behind head they are cycloid (a similar disposition has been reported by Allen for *T. brauni*); this small region, however, may well have been overlooked in M'Coy's material of *T. caudimaculatus*. M'Coy's illustration (pl. 144, fig. 1d) depicts the palatine teeth as being in two closely apposed rows of equal length, but in our fish the arrangement is characteristically uniserial, sometimes briefly biserial anteriorly; while the vomerine patch tends to be more diffuse than as figured. The dorsal cephalic pores as depicted for *T. caudimaculatus* are disposed symmetrically : in our fish they are irregularly scattered and are noticeably more numerous behind middle of eye; in front of this they are patterned as in the illustration, but in the group of 4 between posterior nostrils (series (b) in description above) the interval between inner and outer is about 4 times (instead of subequal to) interval between outer and nostril.

In general, proportions recorded by Allen for the Oyster Cove examples examined by him do not differ significantly from those of our north-west coast specimens : there is, however, one marked discrepancy. For eight fish Allen notes middle caudal rays in standard length as 2.8-3.3. For five of the six individuals at our disposal (one imperfect) we find this ratio, measuring, as before, from origin of longest ray (often beneath basal scales) to extreme tip, 4.6, 5.5, 4.3, 5.1, 5.0 (specimens in ascending order of *Ls* from 36.0 to 55.0); compatible with the range 4.3-5.0 reported above for our north-west coast material. When measured between levels of origin of the caudal ridge carrying the procurrent rays and of longest ray tip, caudal length in *Ls* is 4.1, 3.8, 3.4, 4.1, 3.9. It may be noted that in Allen's fig. 1, which provides a comparison of color patterns in species of *Trachinops*, and in which the fish outlines are perhaps to be regarded as being more or less diagrammatic, the caudal of *T. caudimaculatus* is depicted as lanceolate, much as in M'Coy's illustration, quite unlike that of the Oyster Cove specimens. (As a possible indication that not too much significance was intended to be attached to these outline figures it may be remarked the caudal outline shown for *T. brauni* differs noticeably from that in a photograph, fig. 2, of a paratype of that species.)

Species name. Robert Mackenzie Johnston (1844-1918), doyen of Tasmanian ichthyology named his species in honor of Leonard Rodway (1853-1936), doyen of Tasmanian botany. Rodway presented the specimen to Johnston, but it was 'captured by Mr. Hinsby, an enthusiastic collector' — this was doubtless the George Hinsby for whom Johnston, at the next (May) meeting of the Society, named his *Gobius hinsbyi; nomen nudum* = *Nesogobius hinsbyi* (McCulloch & Ogilby, 1912).

Family APOGONIDAE

The local list comprises 5 species: (i) *Dinolestes lewini* (Griffith, 1834), (ii) *Siphamia cephalotes* (Castelnau, 1875), (iii) *Lovamia fasciata* (Shaw, 1790), (iv) *Vincentia novaehollandiae* (Valenciennes, 1832), (v) *Gronovichthys lemprieri* (Johnston, 1883). Of these, (i) is in some recent texts — e.g., Marshall (1964), Scott (1962), Scott, Glover & Southcott (1974) — referred to the monotypic family Dinolestidae; this is, however, not recognised as distinct by Greenwood *et al.* (1966) in their provisional classification of living teleosts.

The rediscovery noted in Part xii (1964, p.99, fig.1) of Johnston's species raised the possibility that records in published Tasmanian lists of *Apogon novaehollandiae* Valenciennes and (the synonymic) *Apogon guntheri* Castelnau, 1872 may have related to that form. However, Part XX (1974b) reported an example of Valenciennes' species.

Observations on some Tasmanian Fishes

Johnston's 1883 species, placed first in *Apogon* Lacépède, 1802, later in *Vincentia* Castelnau, 1872, is here referred to *Gronovichthys* Whitley, 1929. Two further specimens are now reported, together with some general observations on the species.

Genus *GRONOVICHTYS* Whitley, 1929

Gronovichthys Whitley, 1929, *Rec. Aust. Mus.*, 17(6), p.302, footnote. Substitute name for *Amia* Gronow, 1763, non-binomial = *Amia* Meuschen, 1781 and *Amia* Gray, 1854, preoccupied by *Amia* Linné, 1766 (Amiidae, Lepidosteoidei). Type-species *Amia percaeformis* Gray.

Gronovichthys lemprieri (Johnston, 1883)

Apogon lemprieri Johnston, 1883, *Pap. Proc. R. Soc. Tasm.* (1882), p. 142. Type locality: Dunkley's Point, Sandy Bay, Tasmania.
Apogon lemprieri Johnston, 1891, *Pap. Proc. R. Soc. Tasm.* (1890), p.30.
Apogon lemprieri: Macleay, 1884, *Proc. Linn. Soc. N.S.W.*, 9(1), p. 67: Lord, 1923, *Pap. Proc. R. Soc. Tasm.* (1922), p. 67: Lord & Scott, 1924, SYNOPSIS VERTEBRATE ANIMALS TASMANIA, pp. 10, 55: McCulloch, 1929, *Aust. Mus. Mem.*, 5(2), p.172: Whitley, 1929, *Pap. Proc. R. Soc. Tasm.* (1928), p.53, pl.3, fig.2 (ex Johnston MS).
Apogon lempieri [*sic*]: Lord, 1927, *J. Pan-Pac. Res. Inst.*, 2(4), p.44.
Vincentia novaehollandiae: Munro, 1960, HANDBOOK AUSTRALIAN FISHES, p.144, *partim* (*Apogon lemprieri* Johnston as synonym), not fig. 901: Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89(1), p.43, *partim*. Not *Apogon novae-hollandiae* Valenciennes, 1832.
Vincentia lemprieri: Scott, 1964, *Pap. Proc. R. Soc. Tasm.*, 98, p.99, fig. 1: *ibid*, 1970, 104, p.44.

Status. The generic status of Johnston's species has been the subject of considerable attention in Part XII (1964, pp.104-105), where the fish was referred 'with some reservation' to *Vincentia* Castelnau, 1872, the species-type of which, *V. waterhousii* Castelnau, 1872, is regarded by Whitley (1935, p.11) as a synonym of *Apogon conspersus* Klunzinger, 1872 (which has bare priority), a view accepted in the Handbook (Munro 1960, p.144) where synonymization is carried still further by the identification of both these species (together with *Apogon guntheri* Castelnau, 1872 and *Mionorus ramsayi* Fowler, 1908) with *Apogon novaehollandiae* Valenciennes, 1832). The position adopted in Part XII, 'whether these two species [Johnston's and Valenciennes'] should remain in *Vincentia* or whether one or both of them should be relegated to *Gronovichthys* is a problem regarding the solution of which I have no firm opinion,' was in effect maintained in Parts XVII (1970) and XX (1974b), the first of which noted a further example of Johnston's species, while the second recorded a Tasmanian specimen of Valenciennes' (reported from all states except Queensland). The problem is indeed formally insoluble. As pointed out earlier (1964, p.104), Castelnau's genus *Vincentia* established for a species with edentulous palatines (and edentulous vomer?) and having two separate dorsal fins, has at the hands of later writers become, via the synonymization of the type-species with a species having the characters about to be mentioned, the repository for a form possessing toothed palatines and vomer, and differing from all its immediate allies in having the dorsals united.

In the paper in which he established *Lovamia* Whitley (1935) defined *Gronovichthys* thus, 'Similar to *Lovamia*, but with the maxillary reaching vertical of hinder margin of eye; no longitudinal bands on body; dorsal spines weak,' and observed of *Vincentia* 'it may be distinguished from *Lovamia* and *Gronovichthys* by its united dorsals and much greater depth of body, the depth being greater than length of head or about one-third total length.' The extension of the maxillary in *Gronovichthys* to, but in *Lovamia* short of, the vertical of hind margin of eye may be discounted: in the eleven species

of the former genus recognised in the Handbook the maxillary is reported as reaching to level of hind margin of eye only in one species, occurring modally beneath hind one-third or one-fourth of eye, and in one species reaching only to below hind half of pupil: in the seven species of the latter genus it ranges from below middle to below hind one-quarter of eye. Similarly, the depth specifications given as characteristic of *Vincentia* are not definitive, being matched in several species of *Gronovichthys*. We are effectively left with the conjunction of the dorsals as the prime character of *Vincentia*, and with the absence of longitudinal color bands as the main point separating *Gronovichthys* from *Lovamia*. On these bases, which appear to be those adopted in the Handbook, those species there synonymized with *Apogon novaehollandiae*, other than Johnston's species, are to be accommodated with it in *Vicentia*, while species with dorsals separate and body not banded (and not exhibiting characters necessitating their placement in other genera altogether) are to be referred to *Gronovichthys*.

A totally satisfactory solution not being possible, it is felt the most appropriate course is to accept Whitley's 1945 dorsal-fins criterion. *Apogon lemprieri* Johnston, 1883 is accordingly here listed as *Gronovichthys lemprieri* (Johnston, 1883); as far is known endemic to Tasmania. The Tasmanian fish with conjoined dorsals reported in Part XX (1974b, p.179) as *Vincentia novaehollandiae* (Valenciennes, 1832) retains that designation; representing, through acceptable synonymy, the *Apogon guntheri* Castelnau, 1872 of the earlier local lists of Johnston (1883, 1891) and the *Apogon novaehollandiae* Valenciennes, 1832 of the later lists of Lord (1923, 1927) and Lord & Scott (1924).

Attention must be drawn, however, to the possible taxonomic issues raised by the presence, noted below, in the material here considered of the curious largely squamous ridges flanking the anal base.

Additional material. Johnston's single example is not included in the list of fish type-specimens in the Tasmanian Museum by Andrews (1971), and may be presumed lost. It would appear that material noted in the literature other than the type, total length 4 inches (102 mm), 'length of body' 3 1/5 inches (81 mm), from Dunkley's Point, Sandy Bay, southern Tasmania, is confined to two specimens from St Helens, east coast, *Ls* 68,78, detailed descriptions of which are given in Part XII (1964, p.99, fig.1), and one specimen, *Ls* 34, from the same general area reported in Part XVII (1970, p.44). Observations are here made on three additional examples: (a) *Ls* 85, *Lt* 107, (b) *Ls* 92, *Lt* 20, caught on a hook and line at night by Mr Tidey at Coles Bay, east coast, 7 June 1977 (Q.V.M. Reg. No. 1977/5/25), (c) a badly damaged specimen, approximate *Ls* 103, approximate *Lt* 135, speared at an interstate scuba-diving competition at Croppie's Point, north-east coast, 24 December 1973 (Q.V.M. Reg. No. 1974/5/141).

Meristic characters. D. vii; I, 10. A. II, 10 (a), (b); II, 9 (c). P.16 (a); 15 (b), (c). C. 18+3/3 (a); 20+4/4 (b); (c) imperfect. L. lat. 26 (a), 27 (c), 28 (b).

Dimensions at *TLs*. Apart from lengths of dorsal, anal and pelvic rays, which are noted separately in the sections below on length-serial number patterns, those dimensions reported for the 1970 specimen are here recorded (in all cases in which they can be measured satisfactorily) for the present examples (a), (b), (c), in that sequence; these data are followed, first by the overall range for the two 1964 individuals (*Ls* 68,73) and the 1970 individual (*Ls* 34, noted in parentheses, secondly, by some data for the holotype. Entries for the holotype are either calculated from Johnston's table of dimensions ('length of body', 3 1/5 inches (81 mm), being interpreted as standard length), or estimated from a figure made available by Whitley (1929a) from Johnston's memoranda. This figure (overlooked in earlier contributions in the present series) is of the nature of a sketch only: it presents some obvious inaccuracies

in points of detail (e.g., lengths of dorsal spines) and values derived from it can be regarded merely as approximations: they are here marked with an asterisk.

Head 412,424, ---, (377-397),430. Snout 82,76,97(60-88),62. Eye 129,130,146, (136-147),135. Length to vent (middle) 618,631, ---, (571-610),596*. Length to first dorsal origin 374,380, ---, (388-418),404*; to termination, spine 560,587, ---, (543-555),590*, membrane 576,609, ---, (--,--),610*. Length to second dorsal origin 616,640, ---, (587-615),614*; to termination, spine (no post-spine membrane) 744,755(706-734), 671*. Length to anal origin 629,638, ---, (600,629),601*. to termination, spine (no post-spine membrane) 753,772, ---, (748-753),714*. Length to pectoral front of base, 394,391, ---, (365-393),361*, insertion of rays 424,415, ---, (--, --,)398*. Length of pectoral from front of base 280,283,321, (--,--)289*, from insertion of rays 235, 260, 284,(259-265),265*, Longest, 5th-6th, pectoral ray 222,251,238,(227-240),253*. Length to pelvic origin 376,348,408,(353-382),386*. Length of pelvic, total, 318,329,336, (239-324), length of longest ray 258; length of spine 184,185,213,(162-184), --. Length of first anal spine 60,27,140,(33-47),37; of second 140,152,284,(123-145),234. Depth at front of eye 188,207,184,(147-172), 181*; at back of eye 294,337,340,(231-324),277*; at operculum 364,424, ---, (370-424),361*; at vent 341,391,437,(336-353),277*; at termination of anal 188,196,224,(170-206),181*; maximum depth 413,435,437,(384-404),373*; depth (minimum) of caudal peduncle 164,163,184,(147-151),119*.

Johnston recorded also the lengths of 6 first dorsal spines (7,16,15,13,8,3 mm; *Ls* 3 1/5 in.= 81 mm), overlooking the first and hence misnumbering the rest (cf. Part XII (1964, pp. 102, 105) and further discussion below); interestingly enough, his sketch shows 7, though the lengths as shown are well astray. Three further dimensions reported for the holotype (calculated as *TLs*) are here followed by the corresponding variates for the present specimens (a), (b), (c), fish thus in ascending order of *Ls*. Spine of second dorsal 160; 171, 183, 239. Longest ray of second dorsal 234; 259, 264, 286. Longest ray of anal 234; 212, 217, 245. In all three cases there is evident a trend towards increase in relative *(TLs)* length with increase in size of fish.

Other features. Maxilla to 0.8 eye (a); to 0.9 eye (b), (c). Upper jaw projecting slightly (a), (b); lower projecting very slightly (c).

An interorbital width of twice eye or more (2.0,2.4) recorded for the 1964 specimens and employed in Part XII in a key in contrast with 1.0-1.1 eye for *Vincentia novaehollandiae*, as reported by Munro (1960, p.144), was not found in the 1970 fish (ratio 1.14). A ratio near unity is exhibited by the present examples (1.02, 0.89).

A curious feature of the present material is their possession of two ridges, squamous throughout almost their entire length, originating at a point about midway between vent and anal origin, quickly divaricating, each ridge then running back beside the insertion of the anal rays, extending the whole length of the fin base; close to it, and parallel with it except at its termination where it shows some indication of briefly swinging a little laterad. From its origin to shortly beyond the beginning of the anal the structure appears to be largely of a fleshy nature; however, while it probably continues to be of a similar character (though becoming more compressed) its visible outer surface soon becomes wholly ensheathed in scales, the free margins of which now constitute its somewhat obscurely scalloped outer border. In (a) and (b) it reaches a maximum height of almost 2 mm,in (c) of more than 3 mm; with the scales partly in a single partly in a double series. In (a) and (b) the basal scaly fin sheath thus constituted is not, in general, in contact with the fin and is in parts separated from it by more than a millimetre; in (c) it is in part closely applied to the ray bases.

This structure has apparently not previously been reported in this species — there is no mention of it in the diagnosis (Castelnau 1872) of *Vincentia*, and it is not noted

(Johnston 1883) or figured (Whitley 1929a; *ex* Johnston MS) for the holotype, nor in earlier contributions in this series (1964, 1970), nor in the Handbook (Munro 1960), where it appears (species No. 901) as a synonym of *Vincentia novaehollandiae* (Valenciennes, 1832). Its taxonomic significance has not so far been evaluated. While it appears to be clearly distinct from the subcutaneous gland, described (Lachner 1953) as a silvery tube extending from beneath the tongue along each side of the belly and continuing on to the tail, flanking the anal base, that is met with in *Siphamia* Weber, 1909 (including *Adenopogon* McCulloch, 1921) — a mainly tropical and subtropical genus, represented in Tasmania by a single species *S. cephalotes* (Castelnau, 1875) — its curious character, quite different from the usual anal scaly sheath, suggests it is perhaps not wholly unrelated to it.

Relative growth. Several dimensions expressed as *TLs* are found to exhibit a tendency to vary with *Ls*. The following correlations may be noted. Length to vent (middle) $r + 0.982$ (z 2.339), t 8.906**: length to anal origin $r + 0.974$ (z 2.170), t 7.493**: depth of caudal peduncle $r + 0.833$ (z 1.199), t 3.015*. The first two of these correlations are based on the two 1964 specimens, the 1970 specimen and specimens (a) and (b) of the present material; the third on these five individuals together with (c) of the present material. Fairly high values of r, + 0.739, + 0.840 (z 0.948, 1.220). are found for length to origin, to termination of second dorsal, but these correlations are not formally significant (t 1.899, 2.679).

Spines of first dorsal. (i). Complement.- Johnston's description of his specimen (1883, p.142), appearing among the addenda to his first catalogue, gave the dorsal formula as 6.1/10, noting the lengths of the first dorsal spines in sequence as 7,16, 15,13,8,3 mm. Each of our 1964 specimens had 7 spines, increasing in length from first to third, then regularly decreasing backward (the same pattern obtains in later material). It was suggested in Part XII (1964, p.102) that the first spine, which is minute, was overlooked by Johnston; and the matching of the 6 measurements recorded for the holotype with the measurements of spines II - VII of our example resulted in such good agreement as to make it fairly evident that spine I had indeed been missed. No figure accompanied the original description. The sketch found among Johnston's memoranda, to which reference has been made above (see Dimensions as *TLs*) shows, in disagreement with the description, the first dorsal with 7 spines. No attempt appears to have been made to delineate the spines with any precision, and the first spine, shown as rather more than twice as long as (instead of shorter than, or subequal to) the last, is very probably too long.

(ii). Ascendant series.- In Parts XII, XVII it was shown that for the ascendant set of spines $\{x/x$ = I-III$\}$ the plotting of the logarithm of the length of the spine against the logarithm of the serial number of the spine (counting caudad) gives a significantly straight line, i.e., with L = length, N = serial number, $\log L = k \log N + \log b$, which is the convenient rectification of the exponential relation $L = b N^k$. This relation holds good for the present specimens. The parameters of the regression equations for all material examined together with a measure of significance, are set out in table 3 while measured and estimated spine lengths are given in table 4.

(iii). Descendant series.- Earlier, in Parts XII, XVII an attempt to arrive at a formal relationship between spine-length and spine-number in the case of the set $\{x/x$ = IV-VII$\}$ resulted in a formulation in which the differences between the length of the longest spine (III) and the lengths of the spines of the descendant series appear as a first degree function of the (total) serial numbers of the spines, i.e., $\log (L_3 - L_i) = k \log N + \log b$. Equations for this relation were presented, and were recorded as having t values of 6.38, 35.33** (Part XII), 40.12** (Part XVII). As a result of subsequent investigations into length-number patterns exhibited by dorsal spines (and other ray elements) it has been found (Part XIX, 1974a and later contributions) that over a range of widely diverse species a significantly linear graph

is obtained for descendant series by plotting the logarithm of the length of the spine against the logarithm of the serial number of the spine, counting *cephalad* (slope hence positive, as for ascendant series): if lengthy, the descendant suite may prove to be divisible into subsets, each of which is then treated independently, the last (posterior) spine of the subset being treated as the first and plotted on log 1. If N^1 = serial number of spine of set or subset, counting forwards, the rectified equation is thus $\log L = -k \log N^1 + \log b$. Equations for the spines of the descendant series have been calculated in accordance with this later (more elegant) formulation both for the earlier material and for the present examples. The parameters, together with t values, are shown in table 3; measured and estimated spine lengths appear in table 4.

(iv). Slopes and intercepts of graphs.- For slope and *Ls* there are tolerably high values of r. For {x/x = I-III} in five specimens r = + 0.893 (z = 1.439), t = 3.447*, for {x/x = IV-VII} in six specimens r = — 0.864 (z = 1.312), t = 3.445*. With the value of k held constant, the magnitude of the intercept would be a simple correlate of length of fish. Though such constancy does not obtain, the effective increase in the value of $\log b$ in passing from smaller to larger individuals is such as to result in a significant positive correlation between the constant of the regression equation and *Ls* For the ascendant series of spines in 6 specimens r = 0.922 (z = 1.608), t = 4.791*, for the descendant set r = 0.976 (z = 2.233), t = 8.518**.

(v). Relative growth of spines.- Table 5, the data for which covers our measured material, records the lengths of all spines of the first dorsal as permillages of standard length. A general tendency for relative length of spine to increase with age is evident. The table shows also the ratio in each fish of the length of the longest to the shortest spine in both the ascendant and descendant series. It will be seen that in the descendant set the last spine of the set is shorter relative to the first in small individuals (correlation in 6 individuals of the exhibited ratio with *Ls*: r = — 0.868, z = 1.326, t = 4.406*). In the ascendant set also the ratio longest/shortest spine of set also presents a formal negative correlation with *Ls*. This, however, is very small (for 5 specimens r = — 0.131, z = 0.131) and is not statistically significant. The sense of the correlation is in great part determined by the unexpectedly large value for the individual of *Ls* 34: it could well be that the actual trend is that shown by the 4 remaining specimens, which, taken by themselves, yield r = + 0.910 (z = 1.527), t = 4.387*.

The general conformation of the first dorsal fin thus undergoes considerable change in the course of development, with (if the trend shown by our specimens of *Ls* 65-92 is characteristic) the front spines not keeping pace, and the hind spines outstripping, the central spines in relative size.

(vi). Interspinous areas under graph.- Attention may be called to an interesting point of symmetry exhibited by the larger individuals. In the two Coles Bay examples the area under the graph of {x/x = I-III} — areal unit, logarithm of length of spine, mm, by interval between logarithms of relevant serial spine-numbers — is 0.4183 for specimen (a), 0.4379 for (b); for the graph of {x/x = IV-VII} the corresponding values are 0.6104, 0.6542. With 3,4 spines respectively in the two sets there are 2,3 interspinous areas (panels): for the ascendant set the mean areas for (a), (b) are 0.214, 0.219, respectively, and for the descendant set 0.203, 0.218. Thus in each fish the ratio of the mean panel area of the ascendant set to that of the descendant set is virtually unity. In the other large individual of the present series, (c) of *Ls* 103 the spine was cut away in capture. By extrapolation of the line joining the plots of the logarithmic lengths of spines II, III on logs 2,3 the mean area comes out at 0.236 — giving, with mean area in descent set 0.250, a ratio between these means of 1.06.

This virtual equality is not found in the other specimens examined. In the 1964 material the corresponding pairs of mean panels are for (a) 0.1882, 0.1438, for (b) 0.1913, 0.1596; for the 1970 specimen 1.014, 0.08603. With six specimens in ascending order of standard length the ratios of mean ascendant and descendant panels are thus 1.174, 1.278, 1.194, 1.054, 1.005, 1.057. The sample is of course a short one, and the data for the small 1970 individual stand outside the general trend manifest in the rest of the material of an approximation towards unity. The available data thus prompt the interesting speculation as to whether this equality found in the larger individuals (probably at, or close to, adult size) of the relevant mean areas in the ascendant and descendant sets of spines of the first dorsal is a norm, a geometrical ideal towards which through the course of development the fish tends, attaining it at full maturity — Aristotle and Plato syncretized.

Anal rays. The logarithmic length-number pattern of the anal rays has been examined in specimens (a), (b), In other species investigated it has hitherto been found that when a length-number pattern of the form $\log L = k \log N + \log b$ obtains, all radial elements present are comprised in the two or more sets recognizable. The present material proves to be exceptional in that the sets exhibiting the relevant exponential relation are in (a) {1-3} and {6-10; possibly 5-10, 5 being imperfect} and in (b) {1-4} and {6-10}, i.e., in each specimen the ray occurring between the two sets is anomalous, lying outside either of them — in (a) this is ray 4 (17.0 mm) [no data for 5], and in (b) ray 5 (17.3 mm). The equations for the ascendant series are: (a) $\log L = 0.06637 \log N + 1.2355$, all lengths estimated from it being equal to the measured lengths 17.2, 18.0, 18.5; $t = 9.381$*; (b) $\log L = 0.4058 \log N + 1.2770$, estimated and measured lengths again being equal; $t = 104.778$***. For the descendant series the equations are: (a) $\log L = 0.3185 \log N + 0.9437$, yielding estimated (measured) lengths 8.8(8.6), 12.5(13.3), 13.7(13.7), 14.7(14.0); $t = 6.649$*; (b) $\log L = 0.1433 \log N + 1.0979$, giving 12.5(12.5), 13.8(13.9), 14.7(14.7), 15.3(15.2), 15.8(15.8); $t = 39.518$***.

For {log length spines I, II, ray 1} on {log 1,2,3} the graph is just above formal significance for the smaller specimen ($t = 13.571$*), just below it for the larger ($t = 10.759$). Values of k are 1.1189, 0.9715, of $\log b$ 0.7160, 0.8287, respectively. Predicted (measured) lengths 5.2(5.1), 11.3(11.9), 17.8(17.2); 6.7(6.6), 13.2(14.0), 19.6(18.9).

Pelvic rays. Presenting a log length-log number pattern frequently encountered, the ray set {1-4} is specified thus: (a) $\log L = 0.1758 \log N + 1.2556$, estimated (measured) lengths 18.0(18.0), 20.3(20.4), 21.9(21.8), 23.0(23.0); $t = 24.621$**; (b) $\log L = 0.1925 \log N + 1.3141$, 20.6(21.0), 23.6(23.7), 25.5(25.7), 26.9(27.5); $t = 22.178$**; (c) $\log L = 0.2719 \log N + 1.4391$, 27.5(27.5), 33.2(33.1), 27.4(37.2), 40.1(40.0); $t = 80.118$***.

Disposition of certain fins. (i). First dorsal, anal, caudal.- It is found, for both the 1978 specimens, that when the line with coordinates (log 1, log length to angle of mouth), (log 10, log length to caudal origin, i.e., Ls) is drawn, the ordinal values of the lengths, measured between parallels, from tip of snout to first dorsal origin, first dorsal termination, anal origin, anal termination fall on the line at, or significantly close to, abscissal values that are the logarithms of the natural numbers 3,5,6,7,10. For the two 1964 individuals, the measurement length to angle of mouth is not available. However, the remaining five points, plotted as before on logs 5,6,7,10, are significantly collinear; extrapolation of the best straight line back to log 1 yields a reasonable value for length to angle of mouth. The relevant data are set out in table 6.

(ii) Pectoral, second dorsal, caudal.- Again it is found, for both the present specimens, when the line with coordinates (log 1, log length to end of maxilla), (log 10, log length to caudal origin) is drawn, the logarithms of the lengths from tip of snout

to pectoral origin, second dorsal origin, second dorsal termination fall on the line, at, or significantly close to, abscissal values that are the logarithms of the natural numbers 3,5,7. As before, the first dimension (length to end of maxilla) is not available for the 1964 material. However the remaining four points, plotted on logs 3,5,7,10 are significantly collinear: extrapolation of the best straight line back to log 1 yields a reasonable value for length to end of maxilla. The relevant data are set out in table 6.

The fundamental similarity of general pattern of the exponential relationships noted above to that found in a number of other fishes, with important morphological features located on a loglog measurement-count line at modes represented by natural numbers, would seem to indicate the formulations are not purely fortuitous.

TABLE 3

GRONOVICHTHYS LEMPRIERI (JOHNSTON, 1883). DORSAL SPINES.
Parameters, and significance, for 7 specimens of the equations $\log L = k \log N + \log b$, specifying spines I-III, $\log L = k \log N^1 + \log b$, specifying spines IV-VII; where L = length of spines (mm), N = serial number of spine in the set, counting caudad, N^1 = serial number of spine in the set, counting cephalad. The 6 lengths reported for the holotype are assumed to be those of spines II-VII; spine I of 1978 (c) missing.

Specimen	$\log L = k \log N + \log b$			$\log L = k \log N^1 + \log b$		
	k	$\log b$	t	k	$\log b$	t
Holotype	2.0388	0.2315	-	1.1981	0.5042	9.82*
1964 (a)	1.5071	0.4377	21.94*	1.1422	0.4159	8.32*
(b)	1.6617	0.4202	32.23*	1.0792	0.4941	15.52**
1970	1.8758	0.0043	46.80*	1.1814	0.1054	11.16**
1978 (a)	1.6657	0.4705	25.77*	0.7314	0.7861	29.07**
(b)	1.7772	0.4823	61.57*	0.8122	0.8252	16.41**
(c)	1.9706	0.5206	-	0.5649	1.0706	29.71**

TABLE 4

GRONOVICHTHYS LEMPRIERI (JOHNSTON, 1883). DORSAL SPINES.
Lengths, mm, in 7 specimens, as measured and in parentheses as estimated from the equations of table 3. The 6 lengths reported for the holotype are assumed to be those of spines II-VII; spine 1 of 1978 (c) missing.

Spine	Specimen						
	Holotype	1964(a)	1964(b)	1970	1978(a)	1978(b)	1978(c)
I	-	2.7(2.7)	2.6(2.6)	1.0(1.0)	3.0(3.0)	3.1(3.0)	-
II	7 (-)	8.1(7.8)	8.4(8.3)	3.8(3.7)	9.0(9.4)	10.0(10.5)	13.0 (-)
III	16 (-)	14.0(14.3)	16.0(16.3)	7.8(7.9)	18.9(18.4)	22.1(22.5)	28.9 (-)
IV	15(16.8)	11.5(12.7)	13.0(13.9)	6.0(6.6)	17.2(16.8)	20.2(20.6)	26.0(25.4)
V	13(11.9)	9.4(9.1)	10.7(10.2)	4.9(4.7)	13.5(13.6)	16.1(16.3)	21.9(21.9)
VI	8(7.3)	6.7(5.8)	6.9(6.6)	3.2(2.9)	9.9(10.1)	12.5(11.7)	17.0(17.4)
VII	3(3.2)	2.4(2.6)	3.0(3.1)	1.2(1.3)	6.2(6.1)	6.5(6.7)	11.9(11.8)

TABLE 5

GRONOVICHTHYS LEMPRIERI (JOHNSTON, 1883). DORSAL SPINES.
Lengths as permillages of standard length for 6 specimens; also, for each set, the ratio of the length of the longest spine in the set to the length of the shortest in the set; for ascendant set third/first spine, for descendant set fourth/seventh spine.

Standard length mm	Ascendant set				Descendant set				
	I	II	III	III/I	IV	V	VI	VII	IV/VII
34	29	112	229	7.90	176	144	94	36	4.89
68	40	119	206	5.18	169	138	99	35	4.79
73	36	118	219	6.15	178	147	95	41	4.33
85	35	106	219	6.20	202	159	117	73	2.77
92	34	109	240	7.13	220	175	136	71	3.11
103	-	124	275	-	248	209	162	113	2.18

Family CENTROLOPHIDAE

In Part XVI (1969) an account was given of the second reported local example of *Centrolophus maoricus* Ogilby, 1893, *Ls* 307, *Lt* 380 one of several individuals observed milling around a stranded sunfish (presumably *Mola ramsayi* Giglioli, 1883) at Garden Island, Tamar River, northern Tasmania, on 1 September 1966 — it may be observed that Ogilby's species, accepted hitherto by all Australian authors, is regarded by Haedrich (1967) as a synonym of *Centrolophus niger* (Gmelin, 1788); though later Haedrich & Horn (1972) have noted for *Centrolophus* 'one, perhaps two, species', keying both under the one specification. In the 1969 paper some general remarks were made on the Australian centrolophids, and a key to the Tasmanian members of the family, as it is recognized in the Handbook (Munro 1958), was provided. In recent reviews of the stromateoid fishes by Haedrich (1967) and Haedrich & Horn (1972) the genus *Seriolella* Gay, 1849, accommodated in the Handbook, as in the Check-list (McCulloch 1929) in the Nomeidae, is treated as a centrolophid (palate edentulous; toothed in typical nomeids). The three species acceptance of this position adds to the Tasmanian list of centrolophidae are *Seriolella brama* (Günther, 1860) — appearing in the local catalogues of Johnston (1883, 1891) both as *Neptonemus brama* Günther, 1860 and *Neptonemus? travale* Castelnau, 1872 — *S. maculata* (Forster, 1794) — in local catalogues from Lord's first (1923) onward as *S. punctata* (Bloch & Schneider, 1801), or referred to *Neptonemus* Günther, 1860 — and *S. porosa* Guichenot, 1849 — in all local lists as *S. dobula* (Günther, 1869), or referred to *Neptonemus;* Lord (1927, p.14) has *Seriollela* [*sic*]. These three species differ from the four covered by the 1969 key thus: from *Mupus imperialis* and *M. tasmanica* [the writer favors the retention for the second of the genus *Tubbia* Whitley, 1943, in which it was originally described: *Mupus* Cocco, 1840 is a junior synonym of *Schedophilus* Cocco, 1839; some confusion surrounding the dates of publication of Cocco's names has been cleared up by Tortonese (1959)] by having the spinous dorsal originating behind, instead of above, the head and in being distinct from the rayed dorsal (though the two may be contiguous), instead of being fully united to form a single fin; from *Centrolophus maoricus* [this Australasian species is treated by Haedrich (1967) as synonymic with *C. niger* (Gmelin, 1788), type locality, 'Rivers of Cornwall'] by having dorsal origin over pectoral base or just behind axilla, instead of over tip of pectoral fin; from *Hyperglyphe porosa* [*Eurumetopos johnstonii* Morton, 1888, type locality, near Bridgewater, Tasmania, has generally been regarded as a synonym of this species of Richardson's, type locality, 'Coasts of Australia'; both are identified by Haedrich with *H. antarctica* (Carmichael, 1818), type locality, Tristan da Cunha] by having lateral line follow dorsal profile, instead of arching anteriorly and straightening out over anal fin.

TABLE 6

GRONOVICHTHYC LEMPRIERI (JOHNSTON, 1883). LOCATION OF CERTAIN MORPHOLOGICAL LANDMARKS, CHIEFLY FIN ORIGINS AND TERMINATIONS.

Landmarks as specified by the relation $L = bN^k$, rectified in text and table as $\log L = k \log N + \log b$, where L = length, mm, between parallels, from tip of snout to specified point, N = a natural number from the series 1-10. Two formulations: (1) landmarks = {angle of mouth, first dorsal origin, first dorsal termination, anal origin, anal termination, hypural joint}, natural numbers = {1,3,5,6,7,10}; (ii) landmarks = {end of maxilla, pectoral origin, second dorsal origin, second dorsal termination, hypural joint}, natural numbers = {1,3,5,7,10}. Four specimens: length to angle of mouth, length to end of maxilla not available for the two specimens, 1978(b), 1964(a) and 1964(a), 1964(b), respectively.

Specimen	$\log L = k \log N + \log b$			Measured (estimated) length, mm, between parallels, from tip of snout to specified point										
	k	$\log b$	t	Angle of mouth	First dorsal origin	First dorsal termination	Anal origin	Anal termination	Hypural joint	End of maxilla	Pectoral origin	Second dorsal origin	Second dorsal termination	Hypural joint
	0.8284	1.0989	60.197***	12.5(12.6)	31.8(31.2)	47.6(47.6)	53.5(55.4)	64.0(63.0)	85.0(84.6)					
1978(a)	0.7406	1.1772	44.204***							15.1(15.0)	33.5(34.3)	52.4(50.3)	63.2(64.3)	85.0(82.8)
	0.7853	1.1759	44.052***	15.1(15.0)	35.0(35.5)	54.0(53.1)	58.7(61.2)	71.0(69.1)	92.0(91.4)					
1978(b)	0.7368	1.2278	26.884***							17.1(16.9)	36.0(38.0)	58.9(55.3)	69.5(70.9)	92.0(92.2)
	0.8172	1.0069	18.330***	- (10.2)	25.6(24.9)	36.9(37.9)	42.0(43.9)	51.1(49.8)	68.0(66.7)					
1964(a)	0.7573	1.0646	16.788**							- (11.6)	26.7(26.7)	39.9(39.3)	48.0(50.7)	65.0(66.4)
	0.7912	1.0614	17.032***	- (11.5)	28.1(27.5)	40.5(41.2)	45.9(47.5)	54.2(53.7)	73.0(71.2)					
1964(b)	0.7814	1.0837	14.827**							- (12.1)	27.9(28.6)	44.9(42.7)	53.6(55.5)	73.0(73.3)

Schedophilus huttoni (Waite, 1910), described from New Zealand, is here reported from Tasmania. It is at once distinguishable from the seven species enumerated above as follows: lateral line scales more than 200 (maximum among other species about 160, *Centrolophus maoricus*), spines plus rays in dorsal 57-59 (maximum 50, *Seriolella porosa*), spines plus rays in anal 38-39 (maximum 35, *Mupus tasmanica* = *Tubbia tasmanica* Whitley, 1943).

An early Australian review of *Schedophilus* and its allies was that of Ogilby (1893).

Genus *SCHEDOPHILUS* Cocco, 1839

Leirus Lowe, 1833, *Proc. R. Soc. Lond.*, 1, p.143. Type-species, *Leirus bennettii*, 1833 (= *Centrolophus ovalis* Cuvier, 1833). Preoccupied by *Leirus* Dahl, 1823, Coleoptera.

Schedophilus Cocco, 1839, *Innom. Messina*, 3(7), p. 57. Type-species, *Schedophilus medusophagus* Cocco, 1839.

Mupus Cocco, 1840, *Maurolico Messina*, 4, p.237. Type-species, *Mupus imperialis* Cocco, 1840 (= *Centrolophus ovalis* Cuvier, 1833).

Lirus Agassiz, 1846, NOMENCLATORIS ZOOLOGICI, p.213. Emendation of *Leirus* Lowe, 1833 (hence same type-species).

Crius Valenciennes, 1848 *in* HIST. NAT. DES CANARIES, Webb & Berthelot, 1835-1850, p.43. Type-species, *Crius bertheloti* Valenciennes, 1848 (= *Centrolophus ovalis* Cuvier, 1833).

Haplocoryphis Gill, 1862, *Proc. Acad. Nat. Sci. Philad.*, 14, p.127. Type-species, *Schedophilus maculatus* Günther, 1860.

Eucrotus Bean, 1912, *Proc. Biol. Soc. Wash.*, 25, p.123. Type-species, *Eucrotus ventralis* Bean, 1912.

Coroplopus Smith, 1966, *Ann. Mag. Nat. Hist.*, ser. 13, 4(1), p.1. Type-species, *Coroplopus dicologlossus* Smith, 1966 (= *Centrolophus huttoni* Waite, 1910).

Schedophilus huttoni (Waite, 1910)
(fig. 3)

Centrolophus britannicus: Hutton, 1904, *Trans. N.Z. Inst.*, 36, p.149 (Sumner specimen). Not *Centrolophus britannicus* Günther, 1860.

Centrolophus huttoni Waite, 1910, *Proc. N.Z. Inst.*, 4, p.109 (11 May); and *Trans. N.Z. Inst.*, 42, p.387 (1 June). Type locality: Kaikoura, South Island of New Zealand — accompanying sunfish *(Mola)*.

Centrolophus huttoni Waite, 1912, *Rec. Canterb. Mus.*, 1(4), p. 318: Phillipps, 1927, *N.Z. Fisher. Bull.*, 1, p.32: Smith, 1966, *Ann. Mag. Nat. Hist.*, ser. 13, 9, p.2, pl.1B (photograph of holotype): Whitley, 1968, *Aust. Zool.*, 25(1), p.51.

Coroplopus dicologlossus Smith, 1966, *Ann. Mag. Nat. Hist.*, ser. 13, 9, p.1., pl.1A (2 figs). Type locality: Off Cape of Good Hope; deepish water.

Schedophilus huttoni: Haedrich, 1967, *Bull. Mus. Comp. Zool.*, 135, p.62 (not *Tubbia tasmanica* Whitley, 1943, in synonymy): Haedrich & Horn, 1972, A key to the stromiateoid fishes, 2nd ed., *WHOI-72-15*; *unpublished manuscript:* Trunov, 1969, *J. Ichth.*, 9(3), p.443.

Material. A specimen 231 mm in standard length, 281 + (caudal imperfect distally) in total length, collected by Mr S. Garcia in the Little Piper River, north coast, Tasmania, 7 April 1974; Q.V.M. Reg. No. 1974/5/118.

Meristic characters. Dorsal with 59 radial elements, spines and rays differentiable with difficulty; first 4 elements seem clearly classifiable as spines (first 2

more rigid, and as preserved without terminal fleshy filaments); the nature of the elements beyond these remains uncertain. Anal with 39 radials, first 3 spinous. Pectoral, left/right 20/20. Pelvic I, 5. Caudal 20 + 5/5, 16 branched. L. lat. *ca.* 220. L. tr., at dorsal origin *ca* 40 + *ca* 80. Gill rakers on anterior arch 5 + 10. Branchiostegals VII. A radiograph made to obtain a count of vertebrae showed observable optical differentiation near the hypurals, but not elsewhere.

Dimensions. The dimensions are recorded as permillages of standard length (231). Length to origin, termination of dorsal 182, 909; of anal 524, 903. Length to pectoral, origin of uppermost ray 214, origin of middle ray 234; length from origin of uppermost ray direct to furthest tip of fin 152; base, direct between insertions of uppermost, lowermost rays 61; shortest direct distance from insertion of lowermost ray to ventral profile (about at pelvic insertion) 83, from insertion of uppermost ray to dorsal profile (above eye) 182; length of longest (7th) ray 134. Length to pelvic 203, length from base of fin to furthest tip 100; length of spine, without filament 26, with filament 43, of longest (4th from spine) ray 95. Length to vent, front, 485, back 502. Head to hind opercular border with, without soft spine 208, 216. Eye 39, snout 61. Interorbital, between uppermost points on eyes 65, across 'hard' dorsum here 48. Oblique length of mouth cleft 56, of maxilla 80. Depth (in parentheses width) at front of eye 139 (69), back of eye 196 (91), operculum 329 (100), vent 385 (89); maximum 390 (113); caudal peduncle, minimum 87 (maximum 35, minimum 17). Lengths of dorsal radials, first 21, second 31, third 39 with filament 52, fourth 48 with filament 70, middle 110, last 41, last but one 55. Lengths of anal radials, first 12 with sheath 22, second 68, third 84, middle 100, last 49, last but one 61.

Description. Elongate, compressed, suboval, sole-like, greatest depth, occurring just in advance of vent, 4.3 thickness there, or 3.4 greatest thickness, or 3.7 in *Ls*. Dorsal profile between mouth and dorsal origin overall moderately convex, with two small gibbosities, first with its centre at level of upper half of eye, second somewhat more distant from first than from insertion of dorsal; chord from front of mouth cleft to dorsal origin at about 45° to anteroposterior axis of fish, height of arc decreasing more or less regularly backward; rest of dorsal profile moderately convex, virtually symmetrical above a line joining base of first dorsal spine to base of last ray, the greatest (median) height of arc slightly more than snout length, or about two-thirds depth of caudal peduncle. The continuation forward of the opercle constitutes a small gently convex segment of the ventral profile in advance of level of middle of eye; behind this, whole profile presents an even, fairly strongly convex sweep (see further, below, under "Some aspects of body form"). Caudal peduncle stout, its depth 1.1 in its length to hypural joint, 1.8 its length to origin of lateral caudal ridge, 2.5 in head.

Fish as a whole decidedly limp, flabby; with a curious capacity to absorb and shortly thereafter to release a liquid. In general when a fish is removed from its jar and held suspended, some excess liquid drains off rapidly in a small stream, sooner or later decreasing to a succession of drops, usually little or no additional liquid later gathering in a dry dish in which the specimen is kept during examination. When this fish is taken out of alcohol, no liquid at all drips off: however, within 10-20 seconds of its being laid flat in a dish some 10-15 cc of liquid makes its appearance, subsequently increasing slowly to almost twice this amount.

Head spongy, most noticeably so on occiput; smallish, its total length 4.62 in *Ls*; rather compressed; in side view more or less rounded, its length little more than its height; snout wide, blunt, moderately convex above, decreasingly so backward to become nearly flat between eyes. Some disperse pores: the only regularly disposed observed are 3 pairs, one behind the other, on lower surface of mandible, first, smallest, just behind tip of jaw, last, longest, near level of middle of gape, distance apart about an

FIG. 3.- *Schedophilus huttoni* (Waite, 1910). A specimen 231 mm in standard length, 281 mm + in total length (caudal distally imperfect), collected by Mr S. Garcia in the Little Piper River, north coast, Tasmania, 7 April 1974; Queen Victoria Museum Reg. No. 1974/5/118. Photo, J.G. Simmons.

eye diameter. Eye small, 5.6 in head, shortest distance from dorsal profile subequal to shortest distance from mouth cleft, 1.7 in interorbital space as measured between uppermost points on eyes, or 1.2 in more or less hard region between eyes; 1.6 snout, which is 3.6 in head; a continuous series of about 50 short bars, upper surface convex, radiating outward from orbit; no specific ocular adipose tissue.

Actual cleft of mouth nearly horizontal, descending very slightly backward, but general course of upper lip more obviously oblique, as maxilla, after becoming visible above first one-third of cleft, turns downward, its greatest direct distance from orbit about one and two-thirds its least. Maxilla reaching to level of front of pupil; its truncate end a little wider than rounded anterior end of premaxilla. Premaxilla not protrusible, tapering evenly backward; its anterior process, exposed on right side of head, at a slightly obtuse angle, slightly bowed forward, its length one-third that of main bone. Lower jaw barely in advance of upper, its width increasing backward to become somewhat more than that of upper jaw.

Teeth in lower jaw in a single series of 80-90 on each side, those in front minute, slender, more or less acute, the first 30 occupying only some 3 mm, or about one-fifth of tooth-line; teeth behind these gradually and evenly increasing slightly in height, but becoming noticeably wider, with width at base about a quarter height, the tips almost all becoming less acute, some distinctly rounded; all somewhat compressed, last 10-12 more widely spaced; in hind third of left jaw half a dozen stouter bilobed teeth, in right jaw several teeth, occupying a normal position in the

series, only about one-third height of those flanking them; edentulous interspace at symphysis short, equal to that occupied by half a dozen teeth. In upper jaw edentulous space at symphysis about twice that in lower jaw; anterior half of toothed portion of jaw occupied by 25 (left)-30 (right) teeth more or less similar to those in lower jaw, but rather more slender and much more widely spaced; behind these a diastema subequal to toothless symphisial space, followed by 8 (left), 9 (right) extremely slender inwardly and forwardly curving, regularly tapering, very acute teeth, subequal in length to those earlier in jaw, very widely spaced, interval between them exceeding their height. Palatines, vomer, basibranchials edentulous. A large palatal frenum, mostly minutely papillose, large, extending forward to within less than a pupil diameter of symphysis, broadly rounded in front.

Gill opening extensive; branchial membranes extending well forward to become continuous over isthmus at level of halfway between snout tip and eye. Gills 4, a slit behind last; gill filaments slender, suddenly tapering distally, longest subequal to an eye diameter. Gill rakers long, curved, subcylindrical, tapering only slightly throughout most of their length, briefly rounding off bluntly distally; their briefly expanded bases about one-fourth their length, close together or contiguous, some minutely denticulate in at least proximal half of upper edge; 5 on upper limb of first branchial arch, 10 on lower limb, longest on lower about twice longest on upper, or about two-thirds longest gill filament; on last arch 8, short, upper rounded, separated by about half their height, lower cylindrical with slight brief terminal expansion, all minutely crenulate distally. Pseudobranchiae present, base about an eye diameter, 15-20 slender tapering filaments, longest (median) about half longest on first branchial arch.

The whole dorsum of the head presents much the appearance of a mass of wax that has been melted and has cooled and solidified irregularly, forming depressions, grooves and openings differing on the two sides of the median line: in the circumstances the true situation in respect of the nostrils, regarding which there is some current confusion, remains uncertain. In the subjoined account approximate measurements are given in mm. On the left side there are in succession backwards: (a) behind upper lip by 2, starting 6 from median line a transverse trough 3½ by 2; (b) overlapping outer end of (a) an irregular flap with a subtriangular depression, apex towards eye; (c) adjoining a minutely mammilate ridge 3 x 1.5, running fore-and-aft, an irregular subquadrangular depression, 5 by 8, reaching to within 6 of eye, its outer edge forming the boundary of (a), its lateral borders slightly elevated, its posterior border, which runs out and somewhat back, forming an overhanging shelf; (d) 17.5 (direct measurement) behind upper lip, 3 from median line (hence in virtually the same position as (c) on left side) a conical depression, the anterior apex shallow, deepening to rectilinear posterior border, which forms a shelf, beneath which the depression continues back for a distance subequal to half its uncovered length, its posterior boundary, completing a long ellipse, discernible through translucent overhanging shelf; (e) at 28 from upper lip (vertically above middle of eye) two depressions, each about 2 in diameter, the anterior slightly transversely elliptical, the posterior, separated by a narrow oblique septum, a little closer to, about 4 from, middle line; (f) starting about 3 behind (e), a little closer to median line an irregular trough 5 long. On right side in succession backward: (g) in a position similar to that of (a), separated from it by a yellowish bar, a subtriangular depression of comparable size, apex directed outward; (h) externad of (g), but (in contrast to situation on left side) quite separate from it, at a little more than two-thirds length of snout, two-thirds of an eye diameter from eye, about one-third this from toothline, in about the same position as (b), a small pocket, into the roofed end of which a seeker enters for rather more than a millimetre; (i) a depression more or less matching (c), but with its posterior margin continued somewhat further back, and not forming so distinct a shelf, and having in the middle of its anterior portion a small lingulate process, partly excavate below, not present in (c); (j) about half as far from hind end of (h)

as from level of front of (d), a shallow depression with posterior shelf, the whole much like (d), but a trifle longer and narrower; (k) on almost same transverse level as (d), starting less than half length of (c) behind level of front border of that depression, a depression similar in form and size, but lacking the posterior shelf: no small depressions matching those of (e) on left are traceable on right, but about twice as far from midline here, swinging externad posteriorly, is an irregular groove, tolerably deep at its hind end, beginning shortly behind (h) and curving outward and backward for about 15, thus ending well behind level of eye.

Operculum very flexible, papyritious; border with small delicate spiniform processes, their number and disposition differing on the two sides of the fish. On left side at upper angle a broad-based bluntly pointed membranous flap, from which project backward and upward 7 delicate pointed processes, the upper 4 each set in a sheet of very delicate hyaline apparently gelatinous membrane, the others, the longest, in a single triangular membranous matrix; halfway between this flap and upper insertion of operculum, a second, smaller flap with two small processes of a similar type; in upper half of hind border, below the group of 7, several minute colorless hair-like processes; near lower angle, where soft membranous subopercular first becomes visible, a group of 5 small spinelike processes, embedded as before, followed below by half a dozen more, minute, spaced along lower border, the most anterior behind level of eye by less than eye diameter. On right side with spiniform processes as follows: at position of upper flap 5, lowest longest; at flap at upper angle 3 extremely slender, all in same triangular membrane; below these, 7, shorter, much stouter, not, or barely, projecting beyond the continuous membrane; about at level of bottom of pectoral base 9 small or very small, more or less equally spaced, the 3 lower pointed backward above interoperculum; below these one pair, with indications of probable existence of others. Preoperculum thin, flexible but less so than operculum. On its border on right side, just above angle, about level with bottom of pectoral base, 4 soft, slender, subcylindrical processes, acutely pointed, uppermost directed back and slightly down, about 4 times as long as lowermost, directed almost vertically down: on left side only 2 found, both directed back and decidedly up, subequal, total length, of which nearly half is enclosed in surrounding tissue, about half an eye diameter. Preopercular border broadly rounded, noticeably bowed back.

Dorsal fin originating shortly behind preopercular border, at two-thirds length of head without snout, in advance of pectoral origin by rather less than an eye diameter, terminating in advance of origin of upper caudal ridge containing minor rays by two-thirds depth of caudal peduncle, or in advance of hypural joint by twice this distance; laid back reaching about two-thirds along caudal ridge, slightly short of level of hypural joint; base fleshy, its length, between parallels, 1.38 in *Ls* or 1.92 anal base between parallels. Total radial elements 59, the first 4 classifiable as spines, but nature of immediately succeeding elements doubtful, probably rays; gradually increasing in height to near middle, thereafter decreasing tolerably evenly; 1st spine 1.4 in 2nd or 10.2 in head, 1.8 in 3rd without filament or 2.4 in third with filament, this last 4.2 in head; ray at middle of series 2.0, last ray but one 4.0, last 5.3 in head. Rays simple, slender, regularly tapering hyaline rods, unbranched, locking any obvious signs of septa, sheathed in pigmented membrane bearing scales for most of its height; terminating in a fine filament extending well beyond end of primary hyaline axis. Anal originating at 0.52 of *Ls*, under about 35th dorsal element, terminating behind dorsal by 0.2 eye; laid back reaching about halfway along lower caudal ridge; base fleshy, its length, between parallels, 1.75 head. Total radial elements 39, similar to those of dorsal and similarly scaled; 1st, 2nd, 3rd spinous; these three without filaments 18.5, 7.1, 5.0 or with filaments 10.0, 5.6, 3.7 in head; ray at middle of series 2.2, last ray but one 3.5, last 4.4 in head. Pectoral pointed, with 10 simple rays; inserted well behind dorsal origin; length to origin of uppermost ray 4.67, to middle of base 4.28 in *Ls*; length from base of uppermost ray direct to furthest tip of fin 6.60 in *Ls* or 1.43 in head; lower 2 or 3 very short, longest (7th) ray 1.61

in head; as preserved, whole base and proximal one-fourth of fin covered with small scales, upwards of 20 on a median ray, beyond this membrane largely missing, but indications of the probable extension of scales beyond middle of length. Pelvic with 1 spine 5 simple rays; originating at 0.20 of *Ls*, about below 3rd dorsal radial, in advance of origin of uppermost pectoral ray by 0.3 eye; lengths of spine, without, with, filament, of longest ray (4th from spine) 8.3, 5.0, 2.3 in head; membrane enveloping rays very delicate, when handled tending to become drawn out into long hair-like extensions; fin reaching 0.35 of distance towards vent, its length 2.1 in head; proximal one-fourth of right and left inner margins attached by two folds of membrane to two parallel ridges, a groove between them; scales wholly covering basal one-third of fin, probably originally extending further. Caudal imperfect, length as preserved equal to head; 20 main rays, about 5 minor rays largely buried in the thick integument of each of the dorsal and ventral basal caudal ridges originating about an eye diameter in advance of level of hypural joint; 16 rays branched, most deeply divided, presenting a somewhat unusual appearance, the central ones divaricating about an eye diameter from their origin, separating briefly and then running subparallel as stout moieties, each of these, beyond the basal one-third of the fin, having the appearance of being a complete ray; a conspicuous opaque semicircular area at base of rays wholly covered with scales, upwards of a score in the median line; beyond this minute scales extending along at least half free length of ray but being wholly absent from membrane, so that portion of fin behind proximal opaque patch of scales is much lighter and partly transparent.

Scales subcircular, small, diameter of largest (covering most of flank) 1.2 mm; rather deciduous, leaving small tumid ovoid areas, sometimes confluent, usually with several small pigment spots; about 240 between operculum and hypural joint; obliquely down and back from dorsal origin about 30 + about 80, rows here somewhat sinuous; covering whole trunk, tail and (see above) a good part of all fins; somewhat variable in size, a tolerably well-defined band, about a dozen wide, of locally smaller scales beginning just above origin of lateral line, running back more or less parallel to dorsal profile to end of dorsal fin, continuing, more narrowly, on to caudal peduncle covering upper one-sixth of it, fairly even in width throughout, about an eye diameter, or about one and a half times its modal distance from dorsal profile; scales immediately behind head mostly smaller than on rest of trunk; hind portion of isthmus tumid, smooth, scales if present well embedded, but normal scales at and near tip; a narrow midventral smooth unpigmented ridge extending forward from vent for two-thirds length of head apparently naked; in upper anterior part of body scales, here small, extending forward to cease at a line (length combined eye and snout) running forward and upward at an angle of about 45° from origin of lateral line to middorsal line, head immediately in front of this, scaleless, spongy; an ovoid area occupying anterosuperior half of portion of operculum bounded below by a line joining tip of opercular flap to bottom of orbit naked, rest of operculum scaled, this being only squamous region of head.

Vent a longitudinal slit, twice as long as wide, in middle of an ovoid mound flanked by two well-developed flaps, diverging from shortly in front of origin of anal fin and embracing whole papilla except middle part of its anterior border, papilla here strongly tumid, descending in front to constitute beginning of smooth midventral ridge already mentioned; a slit present on each side between papilla and flap appears to include an aperture leading inward. Lateral line with about 220 tubercles, closely apposed, slightly elevated; course somewhat irregular, especially anteriorly, including here small local sinuosities that may differ on the two sides; general course as follows, originating immediately behind upper angle of operculum, rising in a sinuous line, about one-third of a head length, by about an eye diameter, to a distance from dorsal profile subequal to its own length; descending in a segment that is a mirror image of the first to level of upper one-third of depth of trunk here; thereafter continuing more or less in a single sweep (some minor sinuosities, more marked on

right side), with gradual decrease of rate of curvature, almost straightening out shortly before level of vent, where it is 1.4 times as far from dorsal profile as from ventral; ending at middle of length of caudal peduncle, being here equidistant from dorsal and ventral profiles.

Coloration. Trunk and tail mostly almost uniform slightly purplish dark grey, somewhat lighter on caudal peduncle and for some distance forward mesially from it with decreasing intensity. Only these noticeable discrete markings: (a) an even strip of off-white with small brownish speckling, about an eye diameter in width, on each side forward from vent to pelvic insertion, in advance of this upper border continuing more or less horizontally, but upswing of ventral profile here converting marking to an elongate triangle, apex near lower jaw; (b) along middle of (a) from vent almost to tip of pelvic the off-white apparently naked ridge noted earlier; (c) at base of each anal ray a subrectangular light grey spot, interval between these from about one-half width of spot anteriorly to one-third posteriorly; (d) on ventral surface a short white stroke in advance of base of first anal spine, dividing into two limbs continuing forward to embrace posterior half of pale grey anal eminence; (e) along whole length of tail above anal base an even light grey band, width about half an eye diameter, distance from profile above anal origin subequal to snout length, decreasing at end of fin to half this, the marking just continuing along lower border of caudal peduncle; (f) a somewhat similar, but rather less intense, light band along whole extent of dorsal base, width decreasing regularly from rather more than an eye diameter in front to about half that behind. Head briefly more or less concolorous with body posteriorly, becoming increasingly lighter forward. Squamous portion of operculum rather more purplish than trunk nearby; naked patch at anterosuperior corner off-white, this color extending over most of rest of head, except immediately below eye, which is light, in part faintly bluish, grey, flecked with a few small spots and short irregular lines of midbrown; a small number of obscure brownish smudges on ventral surface of head.

Fins in general darker than body. Dorsal with each ray bicolor, in front, where anterior border of ray is exposed, hyaline, hind half or two-thirds covered with a sheath (largely squamous) very dark brown, in places approaching black basally; free filamentous tips mostly greyish brown; fin damaged, many elements partly or wholly stripped of membrane hyaline, remnants of membrane brownish or greyish. Anal similar to dorsal. Pectoral base light greyish olivaceous, rather lighter than trunk below it, each scale indicated by a dark brownish fleck; rays largely stripped, then greyish, faintly bluish; membrane where intact dark brownish; proximal one-third of fin scaled, dark brown, also indications of former presence of more distal scales. Pelvics like pectorals, with similar strongly scaled basal area of dark brown. Caudal with fully scaled proximal semicircle concolorous with most of trunk, darker than caudal peduncle; rays partly naked, partly covered with mostly scaled membrane similar to, but overall distinctly lighter than, rays of dorsal and anal.

Some aspects of body form.

(a). Postcephalic ventral profile.- Between the end of the head and the beginning of the caudal peduncle the ventral profile presents a single, aesthetically satisfying, sweep. Ten measurements of the height of the curve above a line joining end of lower jaw and beginning of caudal peduncle have been taken at equal intervals. With Y = this height, mm, and X = decile number of measurement, counting caudad, the curve is well fitted by the polynomial $\hat{Y} = 2.15 + 8.365X - 0.5348X^2 - 0.02266X^3$, measured (in parentheses estimated) values 10.0(9.9), 16.9(16.6), 21.1(21.8), 25.6 (25.6), 27.9(27.3), 29.0(28.2), 26.5(26.7), 22.9(23.2), 17.4(17.6), 9.9(9.7); R 0.9921.

The following four relations are all of the form $Y = bX^k$, where X = dimension, N = a natural number, the exponential formulation yielding a linear graph with loglog plotting.

(b). Relative length of head, trunk, tail.- Let L = 'length to' in the set {end of head, end of trunk, end of tail at hypural joint} and N = {1,2,3}, then the equation of the rectified relation is log L = 1.3738 log N + 1.6860; t = 14.754*; measured (predicted) values of L, mm, 50(49), 116(126), 231(220).

(c). Some fin origins and terminations.- Let L = 'length to' in the set {dorsal origin, anal origin, dorsal termination, anal termination, caudal origin at hypural joint} and N = {1,4,8,8,9} (levels of dorsal and anal terminations virtually the same, both plotted on 8), then log L = 0.7654 log N + 1.6275; t = 11.52**; measured (predicted) values, mm, 42(42), 121(123), 208.5(208.3), 210(208.3), 231(228).

(d). Lengths of dorsal spines.- With L = length of spine, N = its serial number, counting caudad, {1,2,3,4}, log L = 0.5739 log N + 0.6851; t = 22.224**; measured (predicted) lengths, mm, 4.9(4.8), 7.1(7.2), 8.9(9.1), 12.0(12.1).

(e). Lengths of anal spines.- With L = length, N = serial number, log L = 1.3550 log N + 0.4296; t = 74.491**; measured (predicted) lengths, mm, 2.7(2.7), 6.8(6.9), 12.0(12.1).

Distribution. Haedrich (1967) gives the distribution of *Schedophilus huttoni* as 'Seas of New Zealand, eastern Australia and Tasmania', while Trunov (1969) lists as known range prior to publication of his paper as 'New Zealand, Tasmania and South Australia'. There have, however, hitherto been no records for Tasmania. It may be surmised Haedrich's inclusion of Tasmania derives from his treating *Tubbia tasmanica* Whitley, 1943 (holotype taken off eastern Tasmania at 42°42' S, by 148°34' E; a second specimen obtained 'in Tasmanian waters') as a probable synonym of Waite's species, a position later abandoned in the unpublished manuscript key to Stromateoid fishes by Haedrich & Horn (19 2), in which Whitley's species is keyed in *Icichthys:* the present writer is inclined to agree with Whitley (1943a) that *Tubbia* is valid. Trunov's 'South Australia' may be a recent example of a confusion, not infrequent in the last century, between the regional 'southern Australia' and the precise'State of South Australia'. If *Coroplopus dicologlossops* Smith, 1966; from off the Cape of Good Hope is a synonym of Waite's New Zealand species (this identity is here perhaps for the first time expressly proposed), the range of the latter is considerably extended: in any case a distribution along an arc of some four degrees off the west coast of southern Africa has been established by Trunov, who reports 24 specimens taken in this region by no fewer than six vessels.

Discussion.

(a). Generic status of holotype and Tasmanian specimen. Waite (1910) described his species in *Centrolophus* Lacépède, 1802 — keying it off from *C. britannicus* Günther, 1860, *C. niger* (Gmelin, 1758), *C. maoricus* Ogilby, 1893 — and continued this generic attribution (1912), being followed in this both by Australian authors (e.g., Phillipps 1927, Whitley 1968) and by overseas writers (e.g., Smith 1966). It has recently been placed (Haedrich 1966, Haedrich & Horn 1972, Trunov 1969) in *Schedophilus* Cocco, 1839. Features distinguishing *Schedophilus* from *Centrolophus* in the generic diagnoses as given by Haedrich include: (a) head broad, deep (small: the contrast as presented is not between comparable characters; the position is that while in *Schedophilus* the head may be smaller (shorter) than in *Centrolophus*, it is relatively deeper, its depth typically exceeding its length); (b) body deep, maximum depth usually > 0.35 Ls (usually < 0.30); (c) dorsal origin usually before, in very large specimens over, pectoral origin (usually well behind, but in very small specimens over); (d) small spines present (not) on preopercular margin. Comparison with holotype [original description, photograph made available by Smith (1966)]: (a) from figure, apparently longer than high; (b) '4.8 in [0.21 of] the length' (from figure, apparently standard length); (c) dorsal above root of pectoral (specimen large, length 766 mm); (d) no information. The

general weight of the specification thus favours *Schedophilus*. Our specimen seems to be satisfactorily referable to this genus. Two specific characters of *S. huttoni* set it clearly outside *Centrolophus* — dorsal with > 50 (< 45), anal with ≥ 35 (< 30) total radial elements.

(b). Generic and specific status of *Coroplopus dicologlossops* Smith, 1966.- Smith's species, for which he established *Coroplopus*, is known only from the holotype, *Ls* 770, *Lt* 880 mm, from deepish water off the Cape of Good Hope. 'Related most closely to *Centrolophus* Lacépède, 1803, and to the pelagic *Schedophilus* Cocco, 1829 [= 1839], but distinguished from all others in the family by the peculiar nasal opening, apparently single, in a crater-like depression on the side of the snout.' (Smith placed his genus in the Stromateidae; which, with *Centrolophus* and *Schedophilus* cited as the most nearly related genera, is untenable; further, the teeth are of the centrolophid, not the stromateoid, type). After having examined the Tasmanian fish and observed how readily subject it is to damage, with resultant formation of quite varied, apparently random depressions in the head (catalogued above), the present writer is strongly disposed to believe no diagnostic significance is safely attachable to the unusual feature on which the new genus is primarily based. Overall dorsal and anal counts (among the most useful differentiae in centrolophids) at 60, 36 fall within the range of *Schedophilus huttoni*, with other known features of which the description of the South African specimen are in general in good accord. It is accordingly suggested *Coroplopus dicologlossops* is a synonym of this species. With the collection of numerous examples of *S. huttoni* off the western coast of southern Africa (Trunov 1969) no problem of distribution arises.

(c). Comparison of holotype and Tasmanian specimen.- The present specimen is in satisfactory overall agreement with Waite's account of the holotype. The chief differences involve: (i) relative number of spines and rays in dorsal; (ii) presence or absence of pseudobranchiae; (iii) character of nostrils; (iv) certain differences in proportion.

(i). Waite gives 'D.X, 47'; we find IV, 55. Satisfactory differentiation between spines and rays in this fin is very difficult, and probably the only diagnostically useful count is the total — here 57, 59, *cf.* a range of 56-60 (Haedrich & Horn) or 56-63 (Trunov).

(ii). In the holotype the nasal region is described thus, 'nostrils confluent, without septum, the orifice with a narrow rod-like bar; the cavity is close to the end of the snout, and is separated from the eye by a space equal to two-thirds of its diameter'. In our specimen the nostrils cannot be satisfactorily identified (see above). The generic specification (Haedrich, p.60) is 'near tip of obtuse snout, anterior nostril rounded, the posterior a slit.' The reported situation in the probably synonymic *Coroplopus dicologlossops* has already been commented on.

(iii). 'No pseudobranchiae'; present in our specimen (see above). Generic character (Haedrich) 'a few rudimentary rakers present under large pseudobranch'. In *Coroplopus dicologlossops* 'pseudobranchiae are present, small, moderately developed, the filaments long and slender'.

(iv). The length of the holotype is given as 776 mm, that of the Sumner specimen, first noted by Hutton (1904) as 783. It is not clear whether *Ls* or *Lt* is recorded; in either event the New Zealand examples are to be regarded as adult or nearly so. (Of 24 examples reported by Trunov, 16 (not individually specified) had total length 495-796, the remainder, 510-835, including 6 more than 700, all save one females with gonads at stage III of maturity.). Our example, *Ls* 231, *Lt* 281+ may be regarded as juvenile. In *Schedophilus*, as in other centrolophid genera, there are notable changes in proportion with age, allometric growth leading even to qualitative differences in form, thus, for example, the dorsal fin origin migrates caudad relative to pectoral

origin with increase in overall size, so that while the origin is in advance of pectoral origin in smaller individuals (in our fish by almost an eye diameter in front of insertion of uppermost pectoral ray) it is over the fin in larger specimens (in holotype 'above the root of the pectoral'). Relative length of pectoral decreases with growth; in the present specimen 0.70, in holotype 'half' head length: similarly for pelvic (in some species fin may reach to vent in young); length here 2.6, in holotype equal to, eye diameter. The shape of the pectoral of the holotype is not noted: Haedrich states that in this genus it is rounded in the young, pointed in the adult, however, it is here pointed. The most obvious difference between the New Zealand and the Tasmanian fish is the general shape, the former having depth in standard length 4.8, the latter 2.6: decrease in relative height with increase in age is a normal characteristic (in Smith's holotype, *Ls* 770, *Lt* 880, the corresponding value is 3.8). Coloration also is an age character, simple patterns — light horizontal stripes in present specimen and in *S. griseolineatus* (Norman, 1937) and occasional vertical bars and mottlings found in the young becoming less conspicuous or being lost in the adult. No markings are noted for Waite's holotype (laconically specified as 'faded'), for Trunov's material, or for Smith's holotype.

(d). Comparison of Tasmanian specimen and Atlantic specimens. The account of Trunov, based on 24 examples from the southeastern Atlantic, is in the main in quite good agreement with other available information on this species. His material provides an upward extension of 3 in the range of dorsal radial elements: no data on pseudobranchiae, or on presence or absence of spinous processes on margin of preoperculum. Scales are noted as 'slightly ctenoid'; in our example cycloid. At 5-6 + 1 + 11-13 the number of gill rakers on the anterior arch exceeds our count of 5 + 10. Maxillary is stated to extend to anterior margin of eye; here, to pupil. The Atlantic fish seems clearly to be conspecific with the Australasian one; however, the possibility of there being subspecific distinction between them is not wholly to be discounted.

Family OSTRACIONTIDAE

In the first two published Tasmanian lists (Johnston 1883, 1891) and in the contemporary Australian catalogue of Macleay (1882b) the family appears as the old wide group Sclerodermi, in subsequent local lists (Lord 1923, 1927, Lord & Scott 1924) as Ostraciidae. More recent Australian writers have oscillated between Ostraciidae — the form used in the synoptic classifications of Jordan (1923), Berg (1940), Lagler, Bardach & Miller (1962) — and Ostraciontidae, adopted in the provisional general classification of Greenwood *et al.* (1966), and accepted here.

Three species occur in Tasmania: (i) *Aracana aurita* (Shaw, 1798), (ii) *Aracana ornata* (Gray, 1838), (iii) *Lactoria diaphana* (Bloch & Schneider, 1801); (i) and (ii) being fairly common, while (iii) is known locally from two examples only, the second being here reported. In their general text, p.93 (but not in their initial list of species, p.14) Lord & Scott include also *Aracana spilogaster* (Richardson, 1840) (entered as *A. spilogastra* Gray) and *Aracana flavigaster* (Gray, 1838), entries that appear also in the South Australian catalogue of Waite (1923), and, together with three varieties, in the revision of the genus Aracana and its allies by McCulloch & Waite (1915), and in the Australian Check-list (McCulloch 1929); however, it has been shown these are, respectively, the female of *A. aurita* and the female of *A. ornata* (females lack a conspicuous pattern of five blue loops on the caudal fin present in males).

KEY TO OSTRACIONTIDAE RECORDED FROM TASMANIA

1. Height of carapace ≤ its width. Anal base wholly behind dorsal base (partly under caudal base). Caudal rays simple.....*Lactoria diaphana*
   Height of carapace > its width. Anal base largely under dorsal base (distance from caudal base subequal to length of anal base). Caudal rays distally multifid.....2

2. Supraorbital spine above middle of orbit, directed upwards. Distinct hump on snout in male. Male color pattern spots and lines.....*Aracana ornata*
Supraorbital spine above hind part of orbit, directed backwards. No hump on snout in male. Male color pattern lines only.....*Aracana aurita*

Genus *LACTORIA* Jordan & Fowler, 1903

Lactoria Jordan & Fowler, 1903, *Proc. U.S. Nat. Mus.*, 25, p.278, Type-species, *Ostracion cornutus* Linné.

Lactoria diaphana (Bloch & Schneider, 1801)

Ostracion diaphanus Bloch & Schneider, 1801, SYST. ICHTH., p.501. Habitat unknown.
Lactoria diaphana: Jones, 1955, *Rec. Queen Vict. Mus.*, 3, p.1, pl.1.

Tasmanian history. Though Tasmania lies well outside the normal range of this species — given by McCulloch 1929 as New South Wales (where, it is noted by McCulloch (1927, p.127) as being 'sometimes stranded on our ocean beaches'), South Africa, East Indies, Pacific Ocean, Japan; (Marshall (1964) notes one specimen found on a Queensland beach in 1952) — a specimen from Circular Beach, about 3 km from Bicheno, east coast, has been reported by Miss Heather Jones (Mrs J. Steer). In her paper (1955) she speculated it 'must have been brought down from more northerly waters by the eastern Australian current that brings down the sea snakes of the genera *Hydrus* and *Platurus*, which have only been recorded on the East Coast'. These marine snakes include *Laticauda laticaudata* (Linné, 1758) (see Lord & Scott 1924), *Pelamis platurus* (Linné, 1766) (see Lord 1920, Lord & Scott 1924, Scott 1932), *Hydrophis ornatus* var. *ocellatus* Gray, 1849 (see Scott 1932). It is of interest to note that another member of the order Tetraodontiformes, the Ocean Puffer, *Lagocephalus lagocephalus* (Linné, 1758), appears in the Tasmanian list on the basis of a single individual. In reporting on this specimen, stranded on King Island, Bass Strait, in 1967 Andrews (1970) suggested it 'probably originated in the Southern Indian Ocean and was carried across on the west wind drift current'.

Second specimen. A second local occurrence can be reported, a specimen having been found on a beach at Falmouth, east coast, by Mrs J. Smith on 1 August, 1977 (Q.V.M. Reg. No. 1977/5/35). Like the Circular Beach specimen, the standard length of which was noted as 4.65" (118mm) and the total length as 3.56" (90mm), the present example is immature, having *Ls* 63mm, *Lt* 76mm. Günther (1870) gives adult size as 8½" (216mm).

Meristic characters. D.9. A.9. P.10. C.14. Fin rays simple. Scales of sides mostly hexagonal, occasionally pentagonal or heptagonal: they do not form directly continuous longitudinal lines, but there are about 12-13 contiguous elements between gill opening and end of carapace, about 17 on ventral surface between mouth and vent; from anterior lateral spine 8-9 to eye, 8-9 to caudal base, 10 to paired dorsal spine almost directly above it, 13 to its fellow lateral spine across ventral surface (spinigerous plate included in all counts); about 13 from tip of snout to, and including, median dorsal spine, about 6 between it and caudal base; 4-6 counted obliquely across median dorsal platform.

Other metrical characters. With minor modifications and additions the measurements and proportions conforms with that adopted by Woods (1966, p.120) in his report on the

Ostraciontidae collected in 1946 during Operation Crosswords in the Marshall and Marshall Islands.

Depth of body at pectoral origin 1.80 (35mm); depth of body including median dorsal spine and measured at that point 1.52 (41.5), without spine measured at midpoint of its base 1.80 (35); width across dorsal surface, maximum (without spines) 3.50 (18), minimum 5.04 (12.5); head (tip of snout to upper edge of gill opening) 3.41 (18.5); snout to vent 1.18 (53.5): all in standard length. Snout 1.76 (10.5); eye 2.68 (6.9); interorbital (minimum, at middle of anterior orbital border) 1.75 (10.6); least depth of caudal peduncle 1.5 (10), least width 0.61 (30.5); length of pectoral fin 1.21 (15.3); length of caudal fin 1.42 (13); height of dorsal fin 1.55 (11.9); height of anal fin 1.78 (10.4); gill opening, oblique height 6.38 (2.9); postorbital portion of head 14.4 (1.1); dorsal spine (carapace spines all measured direct from tip to middle of nearer longitudinal margin of base of spinigerous plate) 2.85 (6.5); supraorbital spine, left 2.26 (8.2), right 2.15 (8.6); paired dorsal spines, left 3.70 (5.0), right 3.78 (4.9); lateral spines, first, left 4.20 (4.4), right 4.20 (4.4), second, left 4.74 (3.9), right 4.63 (4.0), third, left 2.85 (6.5), right 2.76 (6.7): all in length of head

Other features. Carapace nearly pentagonal in section, comprising, at level of front of eyes, a dorsal segment gently convex upwards, its chord 13 mm, an upper lateral segment, almost linear, sloping length 13, a lower lateral section, almost linear, sloping length 13, a lower lateral section, almost linear, sloping length 27, and a strongly convex ventral section, chord 50. The chord of the dorsal element makes a little more than a right angle with the upper lateral, which is at about 220° to the lower, which is at about 50° to the chord of the ventral surface: if the last named is resolved into an equilateral triangle the angle at the apex is 130°. The areas of the three sections of the frontal elevation are in the ratio 1.00: 1.36: 1.24. Spines: (a) paired supraorbital, (b) median dorsal, (c) paired lateral dorsal, (d) three pairs along ambitus; (a) largest (c) smallest; (b), (c) and anterior pair of (d) virtually collinear transversely; all directed backward except (a), the downward extension of the axis of which meets the gill slit, located about equidistant from dorsal and ventral profiles. Carapace continuous right up to bases of fins. Mouth terminal, small, subelliptical. Orbit mostly crenulate, a little nearer to anterior than to superior profile, least distance from latter subequal to orbit. Interorbital strongly concave, two spines in width between bases of spines. Gill opening small, subelliptical, downwardly and forwardly oblique, anterior margin crenate. Dorsal fin somewhat falciform, 3rd ray longest; anal rounded; pectoral somewhat falciform, first ray very short, about 3 in last, which is 4 in longest (4th); caudal bluntly pointed.

The plates exhibit marked variation in size, shape and ornamentation. (i). Size.- A cluster of about a dozen surrounding the vent small or minute (less than half a millimetre); small adjoining the upper half of mouth; on front and sides of head modally about 3 mm long, larger on postorbital dorsum, still larger (up to 6) on ventral surface; on trunk small to moderate on dorsal surface, moderate to large on lateral surface, the largest peripheral. (ii). Shape.- Some of those bordering the vent with sides ill-defined, approaching circular or elliptical; of 129 distinctly polyhedral plates on ventral surface (on each side a dozen — including the spinigerous plates — extend partly on to ventral partly on to lateral surface) those with 3,4,5,6, 7 sides number 1,1,30,88,9, respectively. (iii). Ornamentation.- On each side of upper half of mouth 3, between and behind these 4 (2 medium) tuberculate and/or fluted, the margins more or less strongly ctenoid: on most of front of head with/without 5-8 obscure radiating lines, or groups of lines forming pennons widening outward; with/without a score or more extremely fine striae crossing the common rim of adjoining plates and continuing briefly into each plate; with/without up to a dozen minute scattered elevated points; a number of irregularly disposed slightly elevated lines,

sometimes minutely crenulate, extending across from less than half a plate to several plates: on dorsum most with a minute central knob and with fine parallel striae crossing margin normal to it and extending from less than a quarter to more than halfway towards the centre, these features best developed in region in advance of median dorsal spine: on sides of trunk 3-6 fine ridges running parallel to the sides, thus forming contained figures similar to the plate outline; usually a central knob and often a set of radiating lines extending from it to outer border (commonly at an angle there), with/without fine striae crossing border: on anterior portion of ventral surface generally similar to those on flank, but lacking the contained figures: on anterior portion of ventral surface with small rounded elevations, modally 8-10, encircling the central elevation in an irregular ring about halfway between it and scale margin or nearer latter. Supraorbital spines and median dorsal spine with a base in the form of a truncated pyramid constituted of 8 (left supraorbital 7) panels, surmounted by a stout subconical slightly recurved projection, the spine proper; each basal plate with numerous subvertical striae in upper half, with transverse striae across the plate junctions, also, in the case of the spines with a triangular system of 7-8 alternate light and dusky areas, widest above, extending down from upper border halfway or more towards lower. Lateral dorsal spines more conical, without sharp distinction between base and tip, vertically striate throughout most of length: lateral spines in general similar, last strongly compressed dorsoventrally.

Coloration. As preserved the carapace is translucent below a line from mouth cleft to gill slit, briefly upward to level of orbit, thereafter back to within a couple of millimetres of middorsal line at caudal base, marked in all this region only by 7 short subvertical dusky streaks, longest subequal to an eye diameter, equally spaced along the ambitus between level of gill slit and third lateral spine, extending briefly on to both dorsal and ventral surfaces: above this line wholly dark, blackish, except for upper lip, which is brown, and for some partly whitish plates near snout tip spines whitish or translucent, some duskiness at or near tips. Fins white or colorless, except caudal, which is faintly dusky distally. Viscera, visible through carapace, white or off-white.

Some aspects of form. The shape may be formally designated anseriform but perhaps more fitly, if more colloquially, be spoken of as being that of a toy duck, with the characteristic features of the bird form emphasized almost as if by caricature, the rounded 'hull' presenting an exaggeratedly bold sweep both transversely and fore and aft, and the upper half being in part concave; the overall result being almost more duck-like than the duck. Some metrical specifications are noted below.
(i). Ambitus.- The ambitus is almost in the horizontal plane behind the eyes, in advance of which it slopes forward and upward at an angle of about 45°; its greatest height above the ventral surface occurring at the first one-third of the standard length, being slightly less than one-third of its distance, at the same point, from the dorsal profile. With ten measurements of width of fish taken at equal intervals along the anteroposterior axis the outline in plan is satisfactorily defined by a third degree polynomial. Where W = width, mm, N = serial number of decile, counting caudad, $W = 5.59 + 19.853\ N - 2.7057\ N^2 + 0.09810\ N^3$: actual measurements (estimated in parentheses) are 22 (22.8), 37 (35.2), 43 (43.4), 46.5 (48.0), 50 (48.5), 48 (48.5), 46 (45.6), 41.5 (41.5), 36 (36.6), 31.5 (31.6). A specimen of a *Lactoria*, *Ls* 37 (Q.V.M. Reg. No. 1977/5/88) found on a beach in Coolangata, Queensland (species undetermined; not *L. cornutus* (Linné, 1758), the only other form noted in the work of Marshall (1964) on the fishes of the Great Barrier Reef and the coastal waters of Queensland) having come into the writer's hands since the above was written, it was thought of interest to ascertain whether or no in it also the ambitus was satisfactorily specifiable by a polynomial. The corresponding equation is $W = -6.24 + 14.034\ N - 1.6975\ N^2 + 0.04023\ N^3$: measured (estimated) widths, mm, 6.3 (6.5), 15.3 (14.8),

21.4 (21.1), 25.0 (25.0), 27.2 (26.4), 25.0 (25.3), 23.1 (21.9), 19.0 (16.6), 9.0 (10.6), 5.4 (7.0) : R 0.9954.

(ii). Dorsal and ventral profiles.- The dorsal profile presents two major segments, rising steeply concave almost to level of hind border of eye, thereafter being gently convex, the chord sloping down and back. The ventral profile is virtually a single even curve, the hind end, however, becoming subvertical in the last few millimetres. With ten equally spaced measurements of depth of curve below a line joining mouth and midpoint of the briefly squared-off terminal section of the carapace (last measurement including this short section), the outline is tolerably well defined by the following equation (H = depth below chord, mm; N = decile number, counted caudad, as before) $H = 6.82 + 6.224\ N^2 - 0.6663\ N$; H ($\tilde{H}$) 12.2 (12.4), 16.9 (16.6), 20.0 (19.3), 21.7 (21.1), 22.0 (21.3), 20.4 (20.2), 17.3 (17.7), 13.5 (14.0), 9.3 (8.9), 3.1 (2.4). The addition of an N^3 term results in a slight overall improvement in predicted value: $H = 5.03 + 7.812\ N - 1.0106\ N^2 + 0.02087\ N^3$; $\tilde{H}$ 11.9, 16.7, 19.9, 21.4, 21.4, 20.0, 17.4, 13.5, 8.7, 3.0. The respective values of R are 0.9716, 0.9731.

(iii). Lengths to lateral spines.- In this species three pairs of lateral spines are present on the ambitus, the first pair directed at right angles to length of fish, the second and third pointed successively more backward. Their location along the anteroposterior axis is such that the logarithms of the lengths to their insertions, log L, fall collinear when plotted against the logarithms of their serial numbers, log N, the equation of the best straight line, with L in mm, being $\log L = 0.5534 \log N + 1.5388$; $T = 18.772^*$; L ($\tilde{L}$) 34.8 (35.6), 49.2 (50.1), 62.6 (62.2). In the Queensland *Lactoria* mentioned above it is found that in a loglog plot lengths to the first three spines occur, as in *L. diaphana*, on logs 1,2,3, with the rearward fourth spine (not present in *L. diaphana*) following on log 7. $\log \tilde{L} = 0.6191 \log N + 1.0604$; $t = 21.572^{***}$; L ($\tilde{L}$), mm, 11.3 (11.5), 18.4 (17.7), 23.7 (22.7), 37.9 (38.3).

(iv). Distances between lateral spines.- A formally similar relation subsists between intervals between tips of spines of a pair, I, and the ordinal number of the pair, in this case, however, counted cephalad, N^1(giving, as before, a positive slope). The equation, with measurements in mm, is $\log I = 0.5582 \log N^1 + 1.4496$; $t = 23.175^*$; I ($\tilde{I}$) 28.0 (28.2), 42.1 (41.1), 51.5 (52.0). In view of the general tendency towards variability in the lengths of spines, it might seem preferable to employ as the relevant interval the distance between the spine-bearing plates. With measurements, mm, made between the middle of these plates the equation becomes $\log I = 0.5249 \log N^1 + 1.4175$; $t = 21.731^*$; I ($\tilde{I}$) 26.0 (26.2), 39.2 (37.6), 46.4 (46.5). It may be noted that whereas in *L. diaphana* the distance between the fellows of the three pairs of lateral spines increases caudad, in the Queensland species, while the distance increases from first pair to second, it decreases again from second to third, and from third to fourth (fourth less than first) — the two interval-number graphs each with only one degree of freedom thus being, in the present context, trivial.

(v). Location of spines and fins on dorsal surface.- The general dorsal contour is interrupted by four sizable projections — the supraorbital spines (paired), the mid-dorsal spine (median, azygous), the dorsal fin and the caudal fin (not terminal, being followed by a brief ledge on the carapace, the base wholly dorsal, the rays directed up and back at an angle of about 45°). In a loglog plot the lengths (from tip of snout, between parallels) to the insertion of these structures treated as ordinal values are found to be collinear when their abscissal values are whole numbers, {1,4, 6,10}, the equation, with measurements in mm, being $\log L = 0.8015 \log N + 1.001$; $t = 166.000^{***}$; L ($\tilde{L}$) 10.0 (10.0), 30.5 (30.5), 42.5 (42.2), 63.0 (63.5). In the Queensland fish, which possesses a second median spine, the number set is {1,3,5,7,10}. Equation: $\log L = 0.5177 \log N + 1.1221$; $t = 78.153^{***}$; L ($\tilde{L}$), mm, 13.3 (13.2), 23.2 (23.4), 30.3 (30.5), 36.9 (36.3), 43.4 (43.6).

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